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MONTHLY WEATHER REVIEW

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IS OUR CLIMATE CHANGING? A STUDY OF LONG-TIME TEMPERATURE TRENDS

By J. B. Kincer

[Weather Bureau, Washington, D.C., Sept. 29, 1933]

The present wide-spread and persistent tendency toward warmer weather, and especially the recent long series of mild winters, has attracted considerable public interest; so much so that frequently the question is asked "Is our climate changing?" Historic climate has always been considered by meteorologists and climatologists to be a rather stable thing, in marked contrast to geologic climate and to weather. We know there have been major geologic changes in climate and that weather, which is the meteorological condition at any particular time, or for a short period of time, such as a day or a month, is far from stable. Different kinds of weather come and go in comparatively brief, alternating spurts, as it were, or with short periods of irregular length—cool or cold, then warm, and vice versa—succeeding one another with a continuous recurrence that everyone takes for granted. However, an exhaustive statistical examination of these short-period temperature fluctuations fails to disclose any regularity that would afford a basis for forecasting future weather independent of the standard forecasting methods of the Weather Bureau, in which daily synoptic charts play an important role.

The phase of weather, or climate, that is attracting attention at the present time is not these short-period changes from warm to cool, and vice versa, for they are always present, but rather an apparent longer-time change to cool periods that seem to be less frequent and of shorter duration, and warm periods that are more pronounced and persistent. It has been thought that these fluctuations in temperature eventually neutralize one another, or smooth themselves out, when the long-time record is taken into account. In other words, meteorologists consider that climate, which is the normal run of the weather, for a long period of time, is a fairly stable thing, and that the average temperature for, say, any consecutive 20 years, selected at random from a long record, would not differ materially from that for any other consecutive 20 years so selected from that particular record. It appears, however, from the data presented with this study that the orthodox conception of the stability of climate needs revision, and that our granddad was not so far wrong, as we have been wont to believe, in his statements about the exit of the old-fashioned winter of his boyhood days. We are familiar with statements by elderly people, such as "The winters were colder and the snows deeper when I was a youngster", and the like.

Before taking up the matter of long-time temperature trends, a few facts, which prompted this study, and which have been responsible for numerous questions about a possible change in climate, may be cited. When we examine the winter temperature records for Washington, D.C., for example, it is found that for the last 21 winters, 1912–13 to 1932–33, inclusive, 18 have been warmer than normal; that every one of the last 13 of these has been mild, and that the warmest winter of record, going back considerably more than a century, was that of 1931–32. This is in marked contrast with "granddad's day", for the 19 winters of 1854–55 to 1872–73, 14 of which were colder than normal, with 1855–56 the coldest in more than 100 years. The record for New Haven, Conn., may be cited as another example. Here every one of the last 10 winters has averaged warmer than normal; so also have 18 of the last 21, and 33 of the last 45. This record, by the way, goes back to near the close of the Revolutionary War. Farther west, we pick up, at random, the St. Louis record, which shows 13 of tne last 15 winters to have had above-normal temperatures. These records are typical for the central and northern portions of the United States east of the Rocky Mountains.

When we examine the records for other seasons of the year, such as the spring and fall, similar conditions are disclosed. For the spring (March to May, inclusive) we find that in the case of New Haven 20 of the last 24 springs down to and including the spring of 1933, have had above-normal temperatures, which contrasts sharply with the 10 successive springs from 1866 to 1875, every one of which had a mean temperature below normal. The Washington, D.C., records show only eight springs with below-normal warmth during the last quarter of a century.

In St. Paul, Minn., more than 75 percent of the fall seasons for the last 43 years previous to 1933 have been relatively warm, in contrast to the 37-year period from 1840 to 1876, inclusive, during which only 9 were warmer than normal. In Washington, D.C., only 3 of the 25 falls since 1907 have had below-normal temperatures, while 15 of the last 17 months, up to and including September 1933, have had plus departures from normal. With these facts of record, it is not surprising that the even casual observer of weather should ask the question "Is our climate changing?"

It might be stated here, however, that the abnormally warm weather experienced in general for a long time past does not mean that cold periods have been entirely absent. On the contrary, the records indicate that occasional brief spells of abnormally cool, or extremely cold, weather are characteristic of prevailing high-temperature trends. The cold winter of 1917–18 may be cited as an example, coming at a time when the long-time trend was running comparatively high, and also the fact that the lowest official temperature of record for the United States—66° F. below zero—occurred in the Yellowstone National Park in February 1933.

For a more fundamental study of the matter, we have adopted a system of moving 20-year summations of temperature data, employing the longest records available. That is, on the accompanying graphs, the first point

represents the sum of the mean annual temperature data for the first 20 years of the record, or years nos. 1 to 20; the second point a like sum for the years nos. 2 to 21, and so on, step by step, throughout the entire record. This, of course is equivalent to the usual floating, or moving-average tabulation; summations were used instead of averages to simplify the operation and obviate residuals resulting from computation of means.

The moving average, or summation, expedient is a much better statistical method of approach to questions of this kind than that, frequently used, of computing averages of successive intervals, such as dividing the record into decades, or into 20-year periods, and comparing the means for the successive periods. This is too much of a hit-or-miss affair, with chances great that any existing

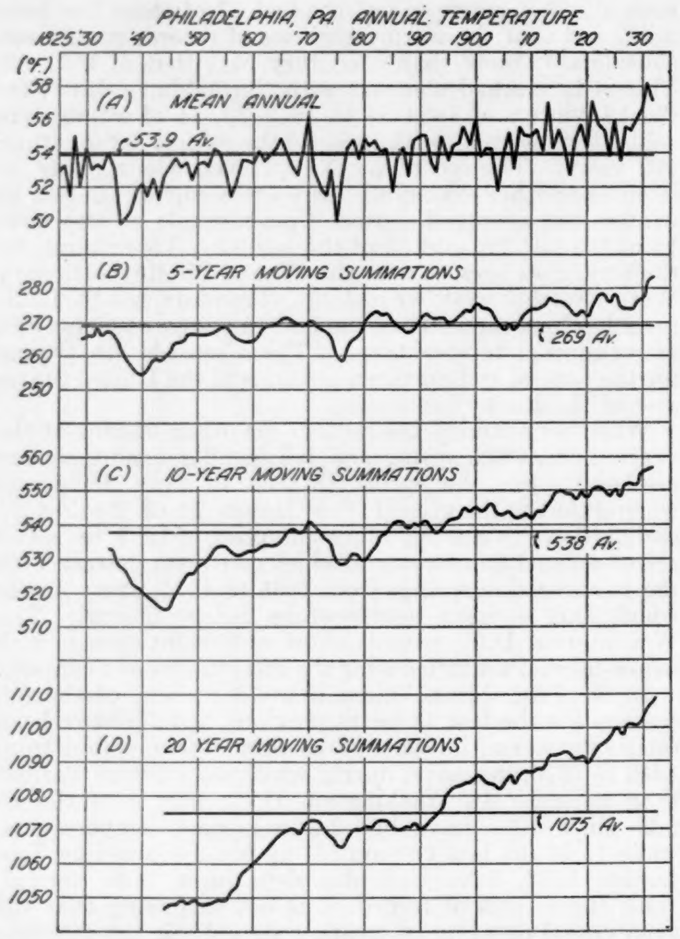


FIGURE 1.—Mean annual temperature, Philadelphia, Pa.; (A) Successive annual means; (B), (C), and (D), 5-year, 10-year, and 20-year moving summations of annual means, respectively. Data in table 1.

trend, especially a short-period one, would be blanketed out by the arbitrary division of periods, depending upon the particular year for which the record may begin, which determines the division points between the periods.

This study shows, as indicated in the accompanying graphs, that temperature trends in middle latitudes of the Northern Hemisphere, and also, though less pronounced, in the Southern Hemisphere, have been prevailingly high for a long time. When the short-period fluctuations in the records are smoothed, by the method just described, into long-time trends (the longest available covering more than 100 years) there is a somewhat irregular, but very definite, upward swing in the curves, shown to have been in progress for more than half a century; and there is, as yet, no evidence of a recession.

The records for the different seasons of the year show that the winters are the most erratic, with up-and-down trends of greater frequency and shorter duration than the other seasons. For the spring and fall the trends have been more uniformly upward, with fewer interruptions

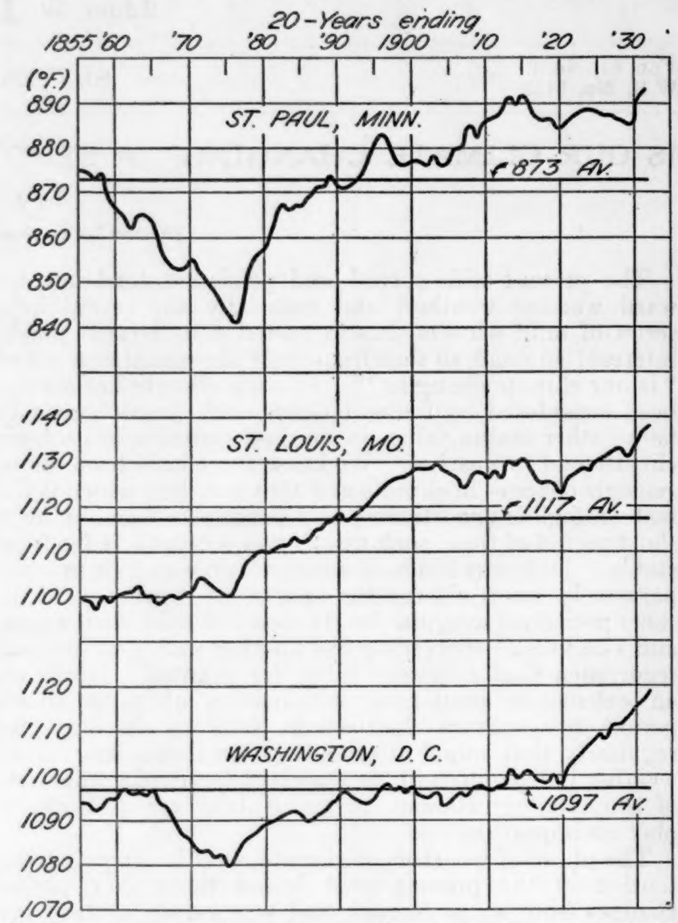


FIGURE 2.—20-year moving temperature summations; St. Paul, Minn., St. Louis, Mo., and Washington, D.C. Data in table 1.

by short cold spells. The curves for the fall season show a remarkably steady upward trend for nearly a century; that is, for nearly a hundred years, our fall seasons have been trending progressively to warmer. The summer curve shows a slight recession from about 1875 to 1912,

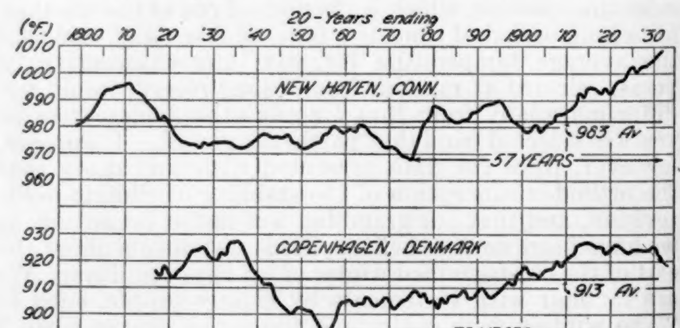


FIGURE 3.—20-year moving temperature summations; New Haven, Conn., and Copenhagen, Denmark. Data in table 1.

but thereafter a moderate rise. For the fall, winter, and spring seasons the averages in temperature for the past 20 years to and including 1933 are from 2.5° to nearly 4° higher than similar averages 60 or 70 years ago. Temperature records of other countries of the Northern

Hemisphere, and also of the Southern Hemisphere, show strikingly similar conditions.

In addition to the graphic presentation, there are included tables giving the temperature records, year by year, on which the respective graphs are based. In table 1, for example, under New Haven, the sum of the first 20 years of data, from 1780 to 1799, is 980.4, charted

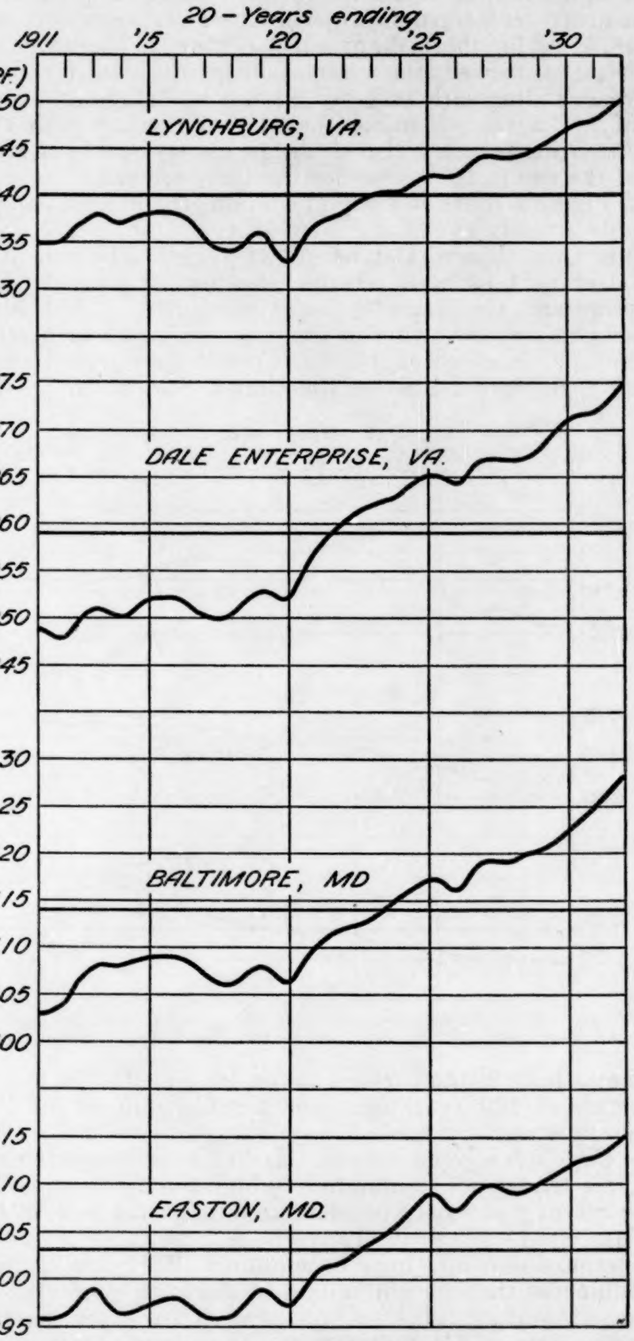


FIGURE 4.—20-year moving temperature summations; Lynchburg and Dale Enterprise, Va., and Baltimore and Easton, Md. Data in table 1.

on the graph under 1799 on figure 3; the second point represents a similar summation from 1781 to 1800, inclusive, charted under the latter year, and so on down to 1932. Dividing these sums by 20, gives, of course, the corresponding averages for the respective 20-year periods.

Figure 1 is based on the temperature record of Philadelphia (table 1) and illustrates the statistical method employed in developing long-time trends. This record began in 1825, by authority of the Pennsylvania Hospital, and was continued by that institution up to and including 1882. Records by the Weather Bureau began with 1872, which gives an overlapping period of 11 years for which two sets of data are available. For this 11-year period the Hospital records average 0.6° higher than those made by the Weather Bureau. It is believed this fairly

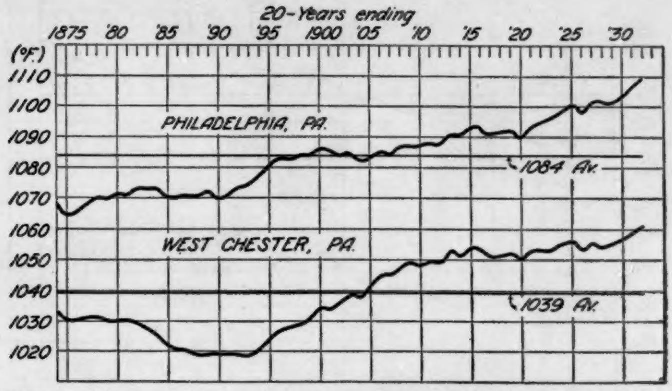


FIGURE 5.—20-year moving temperature summations; Philadelphia and West Chester. Pa. Data in table 1.

represents the difference in the records and, accordingly, 0.6° was subtracted from the Hospital records for each year from 1825 to 1871, inclusive, to make them comparable with the Weather Bureau data; from 1872 to 1932 Weather Bureau records were used.

Figure 1 A represents the mean annual temperature at Philadelphia for the successive years of the entire period,

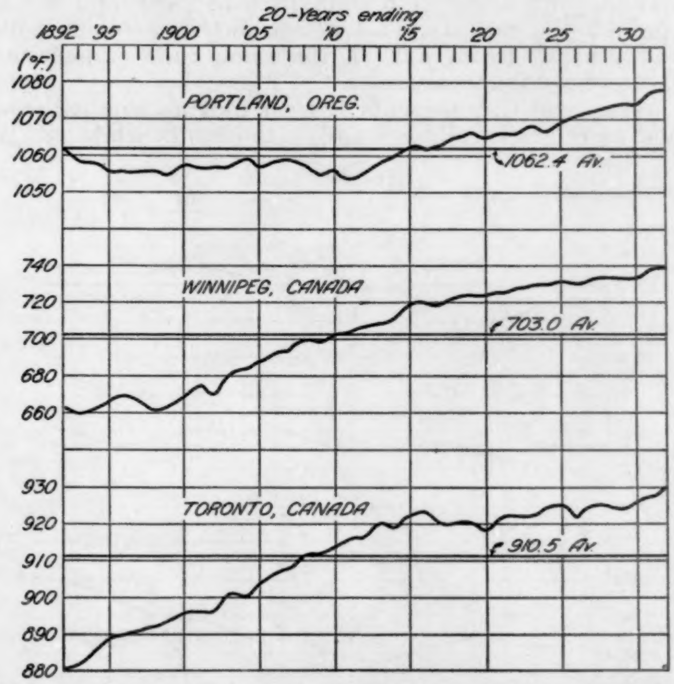


FIGURE 6.—20-year moving temperature summations, representing northern North America (Portland, Oreg., and Winnepeg and Toronto, Canada). Data in table 1.

108, all told. While the annual fluctuations in the graph tend to obscure the long-time trend, there is clear evidence of a very definite upward tendency through nearly the entire record.

The general appearance of the lines from, say, 1835 to 1870 (Hospital record) is strikingly similar to that for 1875 to 1932 (Weather Bureau records). This tends to establish confidence in the old records; also it is obvious

that a least-square, straight-line trend would fit the data nicely from start to finish.

Sub B, figure 1, shows the data smoothed by 5-year moving summations. That is, the first point on the graph represents the sum of the annual temperature values for the 5 years from 1825 to 1829, inclusive; the

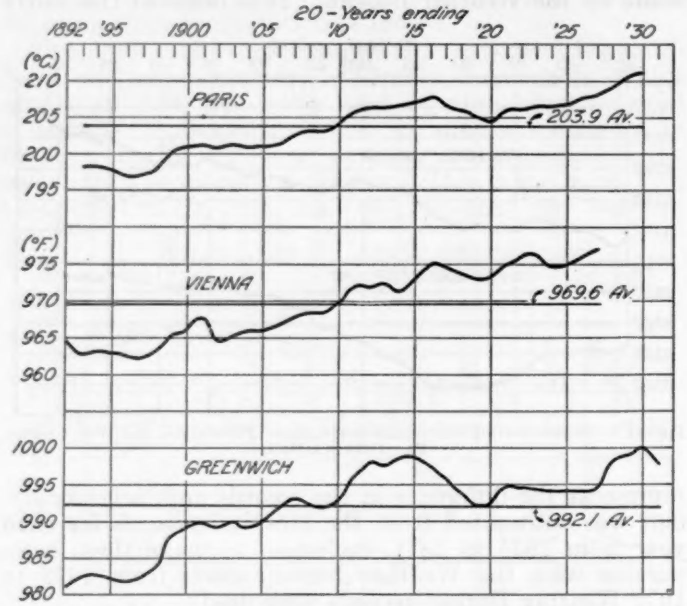


FIGURE 7.—20-year moving temperature summations, representing Europe (Paris, Vienna, and Greenwich). Data in table 1.

second point a like sum from 1826 to 1830, and so on through the record. This brings out, more definitely, the general trend, but at the same time emphasizes short-period fluctuations.

Next, sub C, represents 10-year moving summations, and more graphically establishes the trend, while sub D

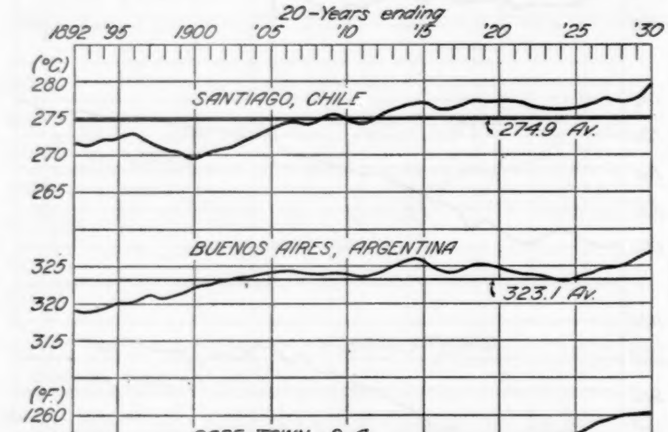


FIGURE 8.—20-year moving temperature summations, representing the Southern Hemisphere (Santiago, Chile; Buenos Aires, Argentina; and Cape Town, South Africa). Data in table 1.

shows the results of a 20-year moving summation tabulation. Here attention is invited to the fact that the sum of the annual temperature data for Philadephia for the 20 years ending with 1844 is 1047°, and for the 20 years ending with 1932 it is 1109°, a difference of 52°, or an average annual difference of 2.6°. If doubt exists as to the realness of this remarkable showing, comparison with similar graphs for other stations in different localities and even different countries, discussed later in this paper, is invited.

Figure 2 (data in table 1) shows, in a striking way, a very definite upward temperature trend for the Midwest and the eastern United States, from the records for St. Paul, Minn., and St. Louis, Mo., for the former, and Washington, D.C., for the latter. These curves indicate a nearly uninterrupted upward temperature swing since 1875, or for more than half a century. Moreover, the trend is marked, the summation for St. Paul for the 20 years ending with 1876 being lower by 52°, or an average of 2.6° a year, than for the 20 years ending with 1932. Attention is called also to the regularity and coincidence of the rise in the curves for the three records.

Figure 3 (data in table 1) contains the longest comparable records available—New Haven, Conn., 153 years; and Copenhagen, Denmark, 134 years. The rise in the latter part of both records, the former going back 57 years and the latter 75 years, is evident. That is, the general upward swing in temperature began in northern Europe, represented by the Copenhagen record, about 20 years earlier than in the United States. A previous

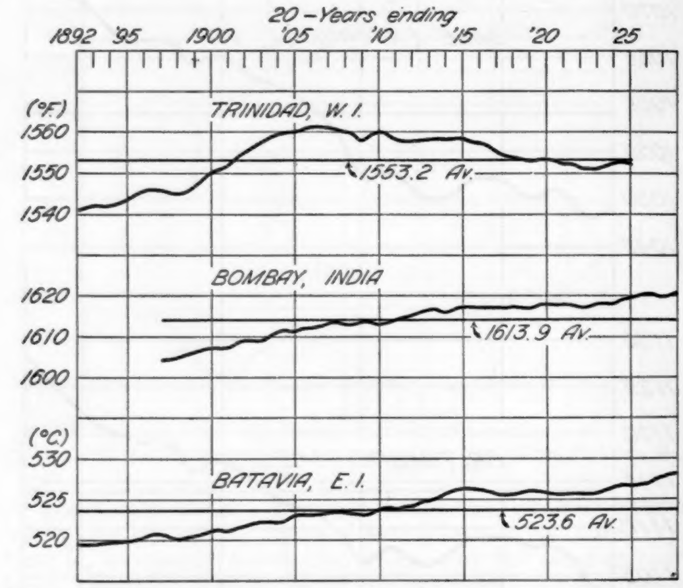


FIGURE 9.—20-year moving temperature summations, representing low latitudes (Trinidad, West Indies; Bombay, India; and Batavia, East Indies). Data in table 1.

major peak in the curve is shown for New Haven in 1810, or about 120 years ago, and for Copenhagen in 1835, nearly a century ago.

City influence on records.—It has been suggested that these tendencies to abnormally high-temperature records in recent years may be more apparent than real, in that data cited are nearly always from large cities where the thermometers may have been unduly affected by artificial influences that do not obtain in the open country. We have examined this phase of the matter and find that the suggestion is not well taken. It so happens that continuous, dependable cooperative records, made in the open country, or in small communities, are available for comparison with nearby city records. Among these are Dale Enterprise, Va., near Lynchburg, and Easton, Md., near Baltimore, which afford excellent comparisons between city and country exposures of instruments. The records from these points are presented in figure 4 (data in table 1) from which it is evident that, if anything, an even more pronounced upward trend exists in the cooperative data than in those for the nearby first-

order city station. These records cover a uniform period of 41 years from 1892 to 1932, inclusive. Corroborating this, figure 5 (data in table 1) contains a much longer cooperative record made at West Chester, Pa., near Philadelphia, covering 78 years from 1855 to 1932, compared with the same period for the latter city. Here again we find the cooperative record showing the same trend, and just as pronounced, as that for the Philadelphia station. These showings definitely dispose of the city-influence argument.

Figures 6 to 9 (data in table 1) are included to give, as nearly as we have been successful in finding, complete comparable records for a uniform period of 60 years for different parts of the world. Figure 6 represents a belt across northern North America, including Portland,

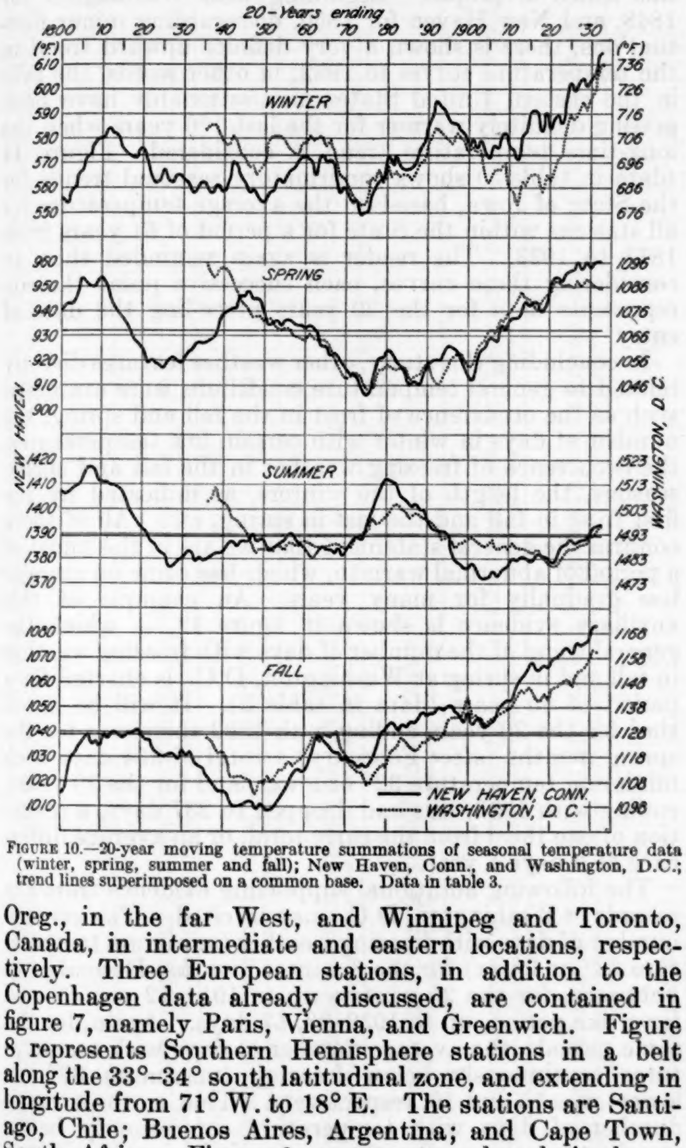


FIGURE 10.—20-year moving temperature summations of seasonal temperature data (winter, spring, summer and fall); New Haven, Conn., and Washington, D.C.; trend lines superimposed on a common base. Data in table 3.

Oreg., in the far West, and Winnipeg and Toronto, Canada, in intermediate and eastern locations, respectively. Three European stations, in addition to the Copenhagen data already discussed, are contained in figure 7, namely Paris, Vienna, and Greenwich. Figure 8 represents Southern Hemisphere stations in a belt along the 33°–34° south latitudinal zone, and extending in longitude from 71° W. to 18° E. The stations are Santiago, Chile; Buenos Aires, Argentina; and Cape Town, South Africa. Figure 9, represents a low latitude, or tropical belt, including Trinidad, W.I.; Bombay, India; and Batavia, D.E.I.

The practically unanimous testimony of these graphs, not only establishes the realness of these upward temperature trends, but shows that they are operative on an extensive geographical scale.

It will be noted that the latter part of the Trinidad record shows a downward trend in opposition to the others. In this connection it may be stated that similar conditions are found to cover low latitudes from the West Indies eastward over northern Africa and the Mediterranean country. A number of stations in this region, such as Alexandria, Egypt, and Palma, Spain, show similar trends. The opposition appears to be confined to this particular region.

Seasonal trends.—In figure 10 (data in table 3) seasonal curves are presented for two long records in the eastern United States—New Haven, Conn., and Washington, D.C.—the former beginning with 1781, and the latter with 1817. These records cover well over a century of

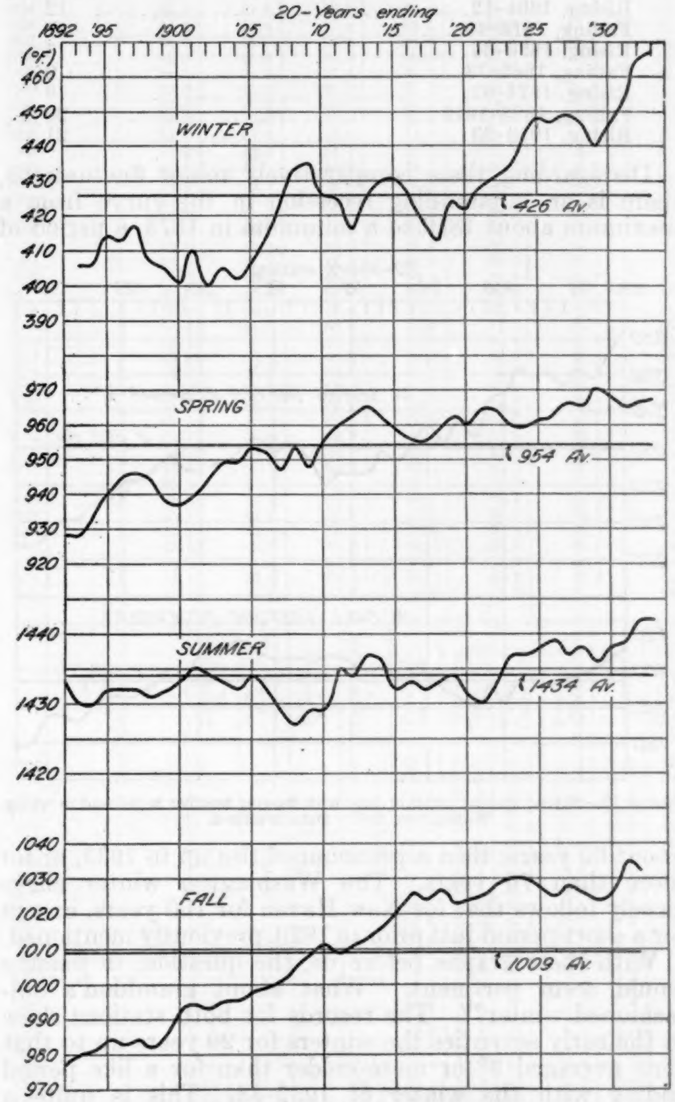


FIGURE 11.—20-year moving summations of seasonal temperature data, averages for all stations in the State of Iowa. Data in table 3.

time and must be credited with offering interesting and corroborative testimony. The four seasons—winter, spring, summer, and fall—are charted separately and, to facilitate comparisons, the lines for each season are superimposed on a common base. The similarity of these trends is remarkable, considering the very considerable distance between the stations. The results show not only that present tendencies to abnormally high temperatures are widespread, even on a seasonal basis, but also by trend concurrence that the fundamental observational data are trustworthy, and are of such character as to afford complete confidence in their integrity.

There is some disagreement for a few years after the beginning of the Washington record but, from about 1845 on, the similarity is striking. A minor winter divergence appears about 1915 to 1920, due to unusually cold weather in Washington being much less severe, relatively, in New England, such as the War winter of 1917–18. An outstanding coincidence is presented in the summer trends during the last 25 or 30 years, largely in opposition to those of other seasons.

Examining these graphs more critically, we find in the case of the New Haven winters very definite, comparatively short-period fluctuations, as follows:

	Years
Rising, 1801–12	12
Falling, 1813–49	37
Rising, 1850–64	15
Falling, 1865–73	9
Rising, 1874–92	19
Falling, 1893–1912	20
Rising, 1913–33	21

Disregarding these comparatively minor fluctuations, there is an outstanding recession in the curve from a maximum about 1812 to a minimum in 1873, a period of

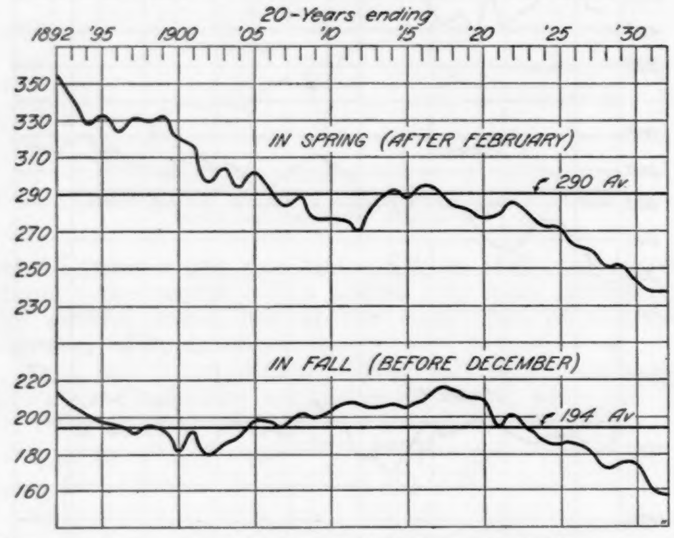


FIGURE 12.—20-year moving totals of days with freezing weather in fall and in spring, Washington, D.C. Data in table 2.

about 60 years; then a pronounced rise up to 1933, or for more than 70 years. The Washington winter curve closely follows that for New Haven for 100 years, except for a short period just prior to 1920, previously mentioned.

With these graphs before us, the question, in passing would seem pertinent, "What about granddad's old-fashioned winter?" The records for both stations show in the early seventies the winters for 20 years up to that time averaged 3° or more colder than for a like period ending with the winter of 1932–33. This is quite a difference in average winter temperature, comprising a span of 3 months, and for a period as long as 20 years.

The trends for the spring months for the two stations show close agreement since about 1845, actually for more than 100 years, because the records extend back 20 years beyond the respective points on the graph. In the case of New Haven there is a comparatively short down, then up trend, with maxima about 1810 and 1845, and minimum in 1825. From 1845 there is a pronounced recession, in both curves, to 1875, or about 30 years; then an even more prominent rise up to the present, or for more than half a century.

For the summer, the highest points for the New Haven curve appear for the 20 years ending with 1807 and that ending with 1881, the maxima being about 75 years apart. The Washington record does not go back to the first New Haven peak, but the second crest of the latter coincides with a similar maximum for Washington in the early eighties. An interesting feature of these curves is the recent comparatively cool summers. In other words, following 1880, while the winters, springs, and falls were becoming definitely warmer, the summers were getting cooler. More recently they, too, show a recovery in the trend lines corresponding with the other seasons.

The fall months show the most remarkable trends in this series of graphs. Beginning with Washington for 1848, and New Haven for 1850, disregarding minor fluctuations, there is shown a very definite upward trend in the temperature curves to 1932; in other words, the falls in the eastern United States unquestionably have been getting definitely warmer for the last 100 years when the long-time temperature trend is considered. Figure 11 (data in table 3) shows confirmatory seasonal trends for the State of Iowa, based on the average temperature for all stations within the State for a period of 61 years from 1873 to 1933. The reader is again reminded that, in considering these curves, each successive point thereon represents data for the 20 years preceding the date of entry.

In concluding this study, other weather features directly related to general temperature conditions were examined such as the occurrence of frost in the fall and spring, the number of days in winter with certain low temperatures, the occurrence of freezing weather in the fall and spring seasons, the length of the winters, as indicated by the first frost in fall and the last in spring, etc. All of these confirm the general statement that we are in the midst of a period of abnormal warmth, which has come on more or less gradually for many years. An example of this auxiliary evidence is shown in figure 12, in which the general trend of the number of days with freezing weather in fall and in spring at Washington, D.C., is charted for a period of 60 years (data in table 2). It will be noted that for the 20 years ending with 1892 there was for the spring months (after February) a total of 354 days with minimum temperature 32° or lower, and for the 20 years, ending with 1933, this had dropped to 237 days, a reduction of one third from the early total, or an average difference of 6 days a year.

The following additional supporting evidence from the records of Washington, D.C., may be cited. The average number of days with freezing weather (minimum temperature 32° or lower) for the 3 winter months, December to February, for the 20 winters up to 1911–12 was 66 and for a like period, up to 1932–33, 57 days. Again, for the same periods, the average number of days with temperatures continuously below freezing (maximum 32°, or lower) was 15 and 10, respectively. That is, the average number of days with temperature continuously below freezing for the earlier 20-year period was 50 percent greater than for the latter. Also, the average length of the frost-free season (number of days from the last killing frost in spring to the first in fall) for the 20 years ending with 1906 was 188 days and for a similar period ending with 1932 it had increased to 199 days.

TABLE 1.—*Mean annual temperature*

Year	Philadelphia, Pa. °F.[1]	St. Paul, Minn. °F.[2]	St. Louis, Mo. °F.[3]	Washington, D.C. °F.[2]	New Haven, Conn. °F.[3]	Copenhagen, Denmark °F.[3]	West Chester, Pa. °F.[4]
1780					49.7		
1781					50.4		
1782					49.1		
1783					48.4		
1784					47.3		
1785					47.7		
1786					48.5		
1787					48.5		
1788					49.7		
1789					49.5		
1790					49.5		
1791					49.5		
1792					48.2		
1793					50.4		
1794					50.2		
1795					49.6		
1796					48.4		
1797					48.1		
1798					49.3	49.1	
1799					48.4	43.9	
1800					50.2	46.4	
1801					51.0	49.3	
1802					51.3	45.7	
1803					50.8	44.1	
1804					49.8	45.3	
1805					51.7	43.7	
1806					49.7	46.9	
1807					49.2	46.8	
1808					50.3	46.0	
1809					49.2	45.5	
1810					50.0	45.3	
1811					49.7	47.8	
1812					46.9	43.9	
1813					49.0	46.4	
1814					48.6	43.5	
1815					47.3	45.9	
1816					46.6	44.2	
1817					46.4	46.2	
1818					46.8	47.1	
1819					49.0	48.0	
1820					47.9	44.4	
1821					47.6	45.9	
1822					49.7	48.6	
1823					48.1	45.7	
1824					49.9	47.7	
1825	52.9				50.8	47.1	
1826	53.3				49.7	48.4	
1827	51.5				48.9	46.4	
1828	55.1				51.8	46.6	
1829	52.0				48.7	42.6	
1830	54.3				50.8	44.6	
1831	53.1				49.2	46.9	
1832	53.3				47.7	46.4	
1833	53.1				48.3	45.9	
1834	54.0				48.9	48.2	
1835	53.0				46.6	45.9	
1836	49.0	43.0	53.2	51.4	45.2	44.8	
1837	50.1	44.1	54.6	53.7	46.4	44.2	
1838	50.7	41.8	53.3	53.7	48.2	41.5	
1839	51.8	47.2	55.3	53.6	49.2	43.3	
1840	52.2	44.8	55.6	53.6	49.0	41.2	
1841	51.5	43.8	55.5	52.9	49.5	44.2	
1842	52.5	43.4	56.1	54.6	49.9	46.6	
1843	51.3	39.8	53.6	53.5	47.4	45.9	
1844	52.7	42.6	56.6	54.0	50.2	43.7	
1845	53.2	45.7	56.3	54.9	50.2	43.3	
1846	53.8	48.2	56.6	56.8	50.1	47.5	
1847	53.2	41.8	53.8	55.2	49.4	45.1	
1848	53.4	42.5	54.2	55.4	49.2	45.5	
1849	52.5	42.2	53.7	55.8	48.3	44.4	
1850	53.4	43.6	55.0	57.1	48.8	44.6	
1851	53.4	46.6	55.2	56.8	49.0	45.5	
1852	53.2	43.7	54.7	54.5	48.8	46.6	
1853	54.3	42.2	54.9	56.0	49.6	44.2	
1854	54.1	44.7	57.3	55.6	49.3	45.3	
1855	53.0	43.6	54.1	54.4	49.0	42.8	52.3
1856	51.4	42.8	52.4	51.7	47.0	44.2	49.9
1857	52.2	41.5	53.0	52.0	47.5	46.9	51.0
1858	53.7	43.9	56.3	54.8	48.3	45.9	51.9
1859	53.6	40.8	54.4	55.0	48.0	47.1	51.5
1860	53.5	43.1	56.5	54.0	48.6	44.2	51.7
1861	54.1	42.2	56.6	54.6	50.1	45.5	52.3
1862	53.6	40.7	55.6	54.1	49.5	44.8	51.2
1863	53.9	42.7	54.4	53.6	50.0	47.3	51.7
1864	54.2	42.6	54.8	54.2	49.9	43.7	52.0
1865	54.9	43.6	56.4	55.0	49.0	45.1	52.5
1866	54.1	40.4	55.2	54.4	48.0	46.0	51.7
1867	53.3	40.1	55.3	53.0	48.0	43.0	51.8
1868	52.6	41.7	54.3	52.4	47.0	47.1	50.4
1869	54.1	42.4	54.1	53.6	47.0	45.7	51.9
1870	56.2	46.1	55.9	55.1	49.0	43.7	53.7
1871	53.0	43.6	57.5	54.8	48.0	42.8	52.3
1872	52.0	41.3	54.1	54.8	48.0	47.7	51.7
1873	51.5	40.6	53.7	54.8	47.9	46.4	51.4
1874	53.0	42.8	56.5	56.0	49.3	46.2	50.6
1875	50.0	39.0	52.8	52.2	48.3	44.6	48.6
1873	52.7	42.3	55.7	54.3	50.8	45.1	50.2
1877	54.3	46.8	56.7	55.5	52.5	44.6	51.6
1878	54.9	48.9	57.4	56.0	52.7	46.9	52.0
1879	53.7	44.8	56.4	55.1	50.8	43.3	50.7
1880	54.9	44.8	56.3	55.6	51.7	45.7	51.6
1881	54.5	46.1	56.9	55.9	49.9	43.7	51.9
1882	54.8	46.3	56.7	54.9	48.8	47.1	50.5

[1] Figure 1. [2] Figure 2. [3] Figure 3. [4] Figure 5.

TABLE 1.—*Mean annual temperature*—Continued

Year	Philadelphia, Pa. °F.[1]	St. Paul, Minn. °F.[2]	St. Louis, Mo. °F.[3]	Washington, D.C. °F.[2]	New Haven, Conn. °F.[3]	Copenhagen, Denmark °F.[3]	West Chester, Pa. °F.[4]
1883	54.1	41.3	54.7	54.0	47.6	45.9	49.5
1884	54.2	44.2	56.2	55.1	48.9	46.8	50.7
1885	51.9	43.1	55.2	53.0	47.4	45.1	49.2
1886	53.8	42.8	56.7	53.4	48.3	45.7	50.2
1887	54.4	42.2	57.6	54.8	48.7	45.1	50.8
1888	52.8	41.2	54.6	53.6	47.2	43.5	49.9
1889	54.8	45.0	56.0	55.1	50.2	45.7	52.4
1890	55.0	43.5	56.8	56.3	49.3	45.9	52.8
1891	55.1	44.0	56.2	55.4	50.0	45.5	53.0
1892	53.5	42.8	55.0	54.0	48.6	45.0	51.5
1893	52.9	41.3	55.2	53.7	47.6	45.1	50.9
1894	55.0	46.1	57.6	56.4	49.7	46.9	53.0
1895	53.6	43.6	55.1	54.2	48.9	45.1	51.8
1896	54.5	44.0	57.9	55.5	48.9	47.1	52.8
1897	54.6	43.7	57.4	54.9	49.5	46.4	52.5
1898	55.6	45.4	57.1	56.1	50.3	46.8	53.7
1899	54.5	44.2	56.6	54.4	49.2	47.1	52.5
1900	56.0	46.5	58.3	56.5	50.7	46.0	54.1
1901	53.8	45.6	57.4	54.1	48.7	46.2	52.0
1902	54.2	45.0	56.6	54.8	49.4	43.9	52.6
1903	54.2	43.5	56.0	54.3	49.2	46.2	52.7
1904	51.8	42.6	54.4	52.2	46.7	46.0	49.9
1905	53.9	44.2	54.9	54.1	48.8	45.9	52.3
1906	55.3	45.1	55.6	55.9	50.4	47.3	53.7
1907	53.1	42.5	55.3	53.5	48.3	45.5	50.9
1908	55.5	46.0	57.4	55.4	50.9	46.0	53.4
1909	55.1	43.7	56.0	55.2	50.1	44.4	52.6
1910	55.0	46.1	55.5	55.2	50.3	47.5	52.4
1911	55.4	44.8	57.5	56.4	50.5	48.0	53.3
1912	54.2	43.2	54.4	54.5	49.9	45.7	52.0
1913	57.0	45.6	57.8	57.3	52.3	47.5	55.0
1914	54.3	44.9	57.4	54.9	49.4	48.2	51.7
1915	55.4	44.8	56.3	55.6	51.1	45.0	53.4
1916	54.3	42.7	56.6	55.0	49.4	46.4	52.3
1917	52.8	40.4	54.0	53.0	47.9	45.5	50.6
1918	54.8	45.0	56.8	55.6	49.8	46.6	53.4
1919	55.7	44.2	57.2	56.4	50.9	45.1	53.4
1920	54.4	44.5	56.0	54.7	49.3	47.1	52.4
1921	57.0	47.5	60.1	58.0	51.9	47.7	54.8
1922	55.7	45.6	58.2	56.4	50.8	44.1	52.8
1923	55.3	45.0	56.7	56.1	49.6	44.6	53.1
1924	53.8	42.1	54.5	54.1	49.3	44.8	51.6
1925	55.9	44.6	57.2	56.1	50.6	46.9	53.3
1926	53.6	43.4	55.8	54.5	48.4	46.9	50.4
1927	55.5	43.3	57.0	56.3	50.7	45.9	53.1
1928	55.4	45.0	56.5	56.0	50.9	45.9	52.6
1929	55.9	42.2	55.2	56.5	50.6	45.0	53.3
1930	56.7	46.3	57.9	57.5	57.5	47.7	54.3
1931	58.1	50.6	59.9	58.2	52.7	45.3	55.3
1932	57.1	44.9	57.4	57.0	52.2		54.3

Year	Lynchburg, Va. °F[5]	Dale Enterprise, Va. °F[5]	Baltimore, Md. °F[5]	Easton, Md. °F[5]	Portland, Oreg. °F[6]	Winnipeg, Canada °F[6]	Toronto, Canada °F[6]	Paris, France °C[7]	Vienna, Austria °F[7]	Greenwich, England °F[7]
1873					52.8	32.8	42.3		50.2	49.3
1874					53.4	34.0	43.8	10.3	48.7	49.7
1875					53.2	30.3	40.6	10.2	47.3	49.8
1876					53.0	30.7	43.9	10.6	48.2	50.6
1877					53.2	36.1	46.0	10.4	48.9	49.9
1878					53.0	40.4	47.1	10.0	49.3	49.7
1879					52.4	32.3	43.9	8.2	46.6	46.3
1880					50.9	31.4	45.4	10.6	49.1	49.5
1881					52.9	34.1	46.1	9.8	46.9	48.8
1882					52.7	33.7	45.4	10.1	50.0	49.8
1883					52.9	29.0	41.5	10.0	48.0	49.4
1884					52.6	30.9	43.4	10.6	48.9	50.7
1885					55.6	31.6	40.8	9.8	48.7	48.7
1886					53.6	33.5	43.4	10.3	48.7	48.8
1887					52.3	31.0	43.9	8.8	47.3	47.9
1888					53.8	32.1	42.7	9.0	46.9	47.8
1889					54.8	36.4	45.5	9.5	47.7	48.8
1890					52.2	33.3	45.1	9.3	48.0	48.7
1891					53.7	34.8	45.8	9.5	47.5	48.4
1892	56.3	53.3	54.1	54.5	52.9	32.8	44.6	10.2	48.0	48.1
1893	55.9	52.3	53.6	54.3	50.1	30.3	43.5	10.8	48.4	51.0
1894	58.2	53.6	55.9	57.5	51.9	36.5	46.7	10.4	49.1	50.0
1895	56.1	50.4	54.2	54.5	52.0	33.9	44.2	9.8	47.3	49.3
1896	57.6	52.6	55.8	55.0	52.6	33.4	45.5	9.8	47.7	50.2
1897	57.3	52.5	55.2	54.3	53.1	34.7	46.4	10.6	48.7	50.4
1898	57.5	52.2	56.3	55.5	52.6	35.2	47.8	10.7	50.2	51.4
1899	56.5	52.0	55.1	54.2	51.9	34.3	46.4	10.8	48.4	50.7
1900	58.4	53.8	57.0	56.4	53.5	36.9	47.3	11.1	49.5	50.5
1901	55.7	51.3	54.4	53.9	52.6	36.3	46.0	10.0	48.6	49.3
1902	56.8	52.8	55.2	55.3	52.6	37.6	46.0	9.9	46.8	49.1
1903	56.4	52.1	55.0	54.9	52.9	35.1	46.0	10.3	49.1	50.2
1904	54.8	50.7	52.6	52.3	54.3	34.1	42.6	10.4	49.3	49.8
1905	56.1	52.1	54.7	54.0	53.3	36.1	45.0	9.9	48.9	49.7
1906	57.5	53.8	56.0	55.6	54.4	37.2	46.2	10.5	49.1	50.5
1907	56.0	51.8	53.6	53.4	53.6	33.8	44.4	10.1	48.6	49.4
1908	56.8	52.7	56.2	55.3	52.9	37.4	46.7	9.8	47.7	49.8
1909	56.9	52.9	55.8	54.7	51.8	35.3	46.1	9.5	47.7	48.6
1910	56.5	52.1	55.7	54.5	53.3	38.0	46.4	10.3	49.3	49.7
1911	58.0	53.9	56.6	55.9	52.2	36.2	47.7	11.2	49.8	51.5
1912	56.5	52.1	55.0	54.8	53.4	36.1	44.8	10.5	47.7	50.2
1913	58.0	55.2	57.9	57.2	52.8	36.3	47.7	10.9	48.7	50.5
1914	56.9	52.8	55.4	54.7	54.5	37.9	46.0	10.5	48.0	50.8
1915	57.2	52.5	55.9	55.5	54.8	38.4	46.8	10.4	48.6	49.3

[5] Figure 4. [6] Figure 6. [7] Figure 7.

TABLE 1.—*Mean annual temperature*—Continued

Year	Lynchburg, Va. °F	Dale Enterprise, Va. °F	Baltimore, Md. °F	Easton, Md. °F	Portland, Oreg. °F	Winnipeg, Canada °F	Toronto, Canada °F	Paris, France °C	Vienna, Austria °F	Greenwich, England °F
1916	57.0	52.2	55.2	55.1	51.5	34.2	46.4	10.4	50.4	49.5
1917	54.8	51.2	53.4	53.3	54.0	33.5	43.2	9.3	48.2	48.4
1918	56.7	52.4	55.7	55.5	54.8	37.0	46.0	10.5	49.5	50.1
1919	57.8	54.7	56.6	56.4	52.7	36.4	48.3	9.8	47.8	48.4
1920	55.9	52.9	55.2	54.7	52.9	37.4	45.8	10.6	49.3	50.4
1921	59.4	56.5	58.2	58.2	53.8	38.4	49.8	11.5	50.5	52.2
1922	58.1	55.0	56.9	56.2	52.2	38.7	46.3	10.0	47.7	49.0
1923	57.7	54.2	56.6	56.6	54.5	37.8	45.6	10.7	49.5	49.7
1924	55.6	52.1	54.7	54.7	53.7	35.2	44.6	10.3	47.7	49.7
1925	58.0	54.2	56.5	56.4	55.3	36.6	45.9	10.2	49.3	49.7
1926	57.0	52.7	54.7	54.2	56.8	36.2	43.8	11.0	50.2	50.5
1927	58.2	54.4	56.6	55.7	53.8	36.0	46.8	10.5	49.6	49.5
1928	57.3	53.4	56.5	55.1	54.1	38.9	46.6	11.4	-----	50.6
1929	57.5	53.9	56.8	55.1	53.2	35.0	46.0	10.5	-----	49.5
1930	58.9	54.5	58.1	56.2	53.2	37.9	47.4	11.2	-----	50.6
1931	59.2	56.0	59.2	57.4	55.2	41.3	49.4	-----	-----	49.3
1932	58.9	54.5	57.9	56.4	54.2	35.9	47.8	-----	-----	-----

Year	Santiago, Chile, °C.[8]	Buenos Aires, Argentina, °C.[8]	Cape Town, South Africa, °F.[8]	Trinidad, West Indies, °F.[9]	Bombay, India, °F.[9]	Batavia, East Indies, °C.[9]
1873	13.4	16.2	63.3	77.1	80.7	25.9
1874	13.0	15.1	61.9	76.5	79.4	25.6
1875	13.1	15.7	62.1	76.4	80.4	25.9
1876	14.2	16.0	61.7	76.9	80.9	25.9
1877	14.8	16.6	62.5	78.1	79.9	26.3
1878	14.1	15.8	61.2	78.5	79.5	26.6
1879	14.4	16.0	60.9	76.6	79.5	25.8
1880	14.2	15.8	61.6	75.2	79.8	25.6
1881	13.6	16.6	62.4	76.6	80.1	26.1
1882	13.6	15.8	63.1	75.8	79.5	25.8
1883	13.0	16.2	62.4	76.1	81.0	25.9
1884	13.2	16.3	62.1	75.7	80.5	25.8
1885	12.9	15.6	63.1	77.6	80.1	26.0
1886	13.4	15.9	62.9	76.8	80.3	26.1
1887	13.5	16.0	62.8	77.3	80.5	25.7
1888	13.9	16.4	62.2	78.3	79.7	26.2
1889	12.6	15.6	61.9	79.3	80.4	26.4
1890	13.4	15.8	61.8	76.7	80.4	25.8
1891	14.0	16.0	62.1	78.5	81.4	26.2
1892	13.2	15.8	60.7	77.4	80.3	26.0
1893	13.2	15.8	62.0	77.6	81.2	25.7
1894	13.6	15.7	62.2	77.1	80.8	25.9
1895	13.6	16.3	61.6	78.1	80.9	26.0
1896	14.5	17.0	62.7	78.3	80.9	26.4
1897	13.9	16.6	62.3	78.2	82.1	26.6
1898	13.0	15.4	61.6	77.6	79.9	26.1
1899	13.8	16.4	62.2	78.8	81.1	26.0
1900	14.0	17.1	62.6	78.5	80.3	26.4
1901	14.2	16.5	62.5	78.5	80.4	26.2
1902	14.0	16.6	62.5	78.9	81.2	26.4
1903	13.7	16.5	60.6	78.6	80.4	26.3
1904	14.2	16.3	61.6	77.2	80.2	25.8
1905	14.0	16.0	62.2	78.2	80.5	26.5
1906	14.0	16.6	61.1	77.7	81.1	26.5
1907	13.5	15.8	61.8	77.5	81.5	26.0
1908	14.0	16.1	61.5	77.3	80.6	26.2
1909	13.6	15.6	63.0	77.5	81.3	26.2
1910	13.0	15.8	63.0	78.0	81.3	26.2
1911	13.2	15.3	63.0	77.4	80.9	26.3
1912	14.0	16.2	63.0	77.1	80.1	26.5
1913	14.4	17.1	62.9	77.2	81.1	26.4
1914	14.0	16.7	62.4	77.6	80.9	26.6
1915	14.2	16.1	63.0	78.0	81.7	26.7
1916	13.7	15.9	62.6	77.0	81.2	26.2
1917	13.8	16.0	62.9	76.3	81.0	26.0
1918	14.0	16.2	63.5	77.1	81.1	26.1
1919	14.3	16.7	63.1	77.8	81.4	26.4
1920	14.0	16.5	63.2	77.7	81.6	26.1
1921	13.7	16.0	62.6	77.7	81.2	26.2
1922	13.5	16.4	62.5	78.2	80.4	26.4
1923	13.2	16.2	62.9	78.1	81.0	26.4
1924	14.0	15.6	62.6	78.7	-----	26.6
1925	14.3	16.6	63.4	78.5	-----	26.6
1926	14.5	17.0	62.6	-----	-----	26.9
1927	14.2	16.7	64.2	-----	-----	26.6
1928	13.8	-----	63.0	-----	-----	26.6
1929	14.0	-----	63.1	-----	-----	-----
1930	14.8	-----	63.7	-----	-----	-----

[8] Figure 8. [9] Figure 9.

TABLE 2.—*Number of days with freezing weather*

Year	Washington, D.C.[10] Spring	Washington, D.C.[10] Fall	Year	Washington, D.C.[10] Spring	Washington, D.C.[10] Fall
1873	-----	18	1904	19	14
1874	21	14	1905	14	13
1875	27	15	1906	21	8
1876	21	8	1907	17	9
1877	17	10	1908	11	14
1878	4	7	1909	15	6
1879	16	14	1910	6	11
1880	17	17	1911	18	16
1881	21	8	1912	17	11
1882	11	13	1913	9	8
1883	26	9	1914	24	11
1884	11	10	1915	20	9
1885	25	5	1916	21	9
1886	12	9	1917	15	14
1887	26	11	1918	9	9
1888	21	7	1919	7	8
1889	9	8	1920	15	5
1890	20	8	1921	5	4
1891	17	11	1922	9	7
1892	18	12	1923	14	6
1893	14	10	1924	12	9
1894	9	8	1925	7	11
1895	13	11	1926	20	8
1896	25	6	1927	7	5
1897	9	7	1928	10	4
1898	11	10	1929	6	9
1899	15	12	1930	8	12
1900	18	6	1931	8	1
1901	8	18	1932	11	8
1902	9	1	1933	9	-----
1903	6	15			

[10] Figure 12.

TABLE 3.—*Mean seasonal temperatures*

Year	New Haven, Conn.[11]				Washington, D.C.[11]				Iowa State[12]			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
1781	32.9	47.1	70.8	50.9	-----	-----	-----	-----	-----	-----	-----	-----
1782	27.4	48.0	70.7	46.9	-----	-----	-----	-----	-----	-----	-----	-----
1783	29.5	46.9	70.3	47.3	-----	-----	-----	-----	-----	-----	-----	-----
1784	23.5	44.0	70.3	51.5	-----	-----	-----	-----	-----	-----	-----	-----
1785	26.5	43.0	70.3	50.3	-----	-----	-----	-----	-----	-----	-----	-----
1786	28.2	47.5	69.5	50.6	-----	-----	-----	-----	-----	-----	-----	-----
1787	27.0	47.3	68.1	49.7	-----	-----	-----	-----	-----	-----	-----	-----
1788	27.3	47.7	70.7	55.8	-----	-----	-----	-----	-----	-----	-----	-----
1789	26.9	46.2	71.9	51.2	-----	-----	-----	-----	-----	-----	-----	-----
1790	32.6	46.4	70.9	52.2	-----	-----	-----	-----	-----	-----	-----	-----
1791	25.1	50.4	69.6	50.0	-----	-----	-----	-----	-----	-----	-----	-----
1792	26.1	48.3	68.2	50.7	-----	-----	-----	-----	-----	-----	-----	-----
1793	29.3	49.4	70.7	51.4	-----	-----	-----	-----	-----	-----	-----	-----
1794	28.8	48.9	69.3	51.2	-----	-----	-----	-----	-----	-----	-----	-----
1795	30.5	46.7	69.5	52.0	-----	-----	-----	-----	-----	-----	-----	-----
1796	28.7	46.1	69.7	50.9	-----	-----	-----	-----	-----	-----	-----	-----
1797	27.1	46.4	70.9	48.2	-----	-----	-----	-----	-----	-----	-----	-----
1798	25.6	48.6	72.1	51.4	-----	-----	-----	-----	-----	-----	-----	-----
1799	24.8	43.5	71.6	51.6	-----	-----	-----	-----	-----	-----	-----	-----
1800	28.2	48.0	71.7	51.5	-----	-----	-----	-----	-----	-----	-----	-----
1801	30.5	49.7	69.8	53.6	-----	-----	-----	-----	-----	-----	-----	-----
1802	32.5	47.9	71.7	54.4	-----	-----	-----	-----	-----	-----	-----	-----
1803	30.4	46.8	71.9	52.3	-----	-----	-----	-----	-----	-----	-----	-----
1804	30.2	48.2	70.7	53.2	-----	-----	-----	-----	-----	-----	-----	-----
1805	27.3	50.3	72.4	53.0	-----	-----	-----	-----	-----	-----	-----	-----
1806	33.8	45.1	73.2	53.0	-----	-----	-----	-----	-----	-----	-----	-----
1807	28.2	45.3	70.3	51.0	-----	-----	-----	-----	-----	-----	-----	-----
1808	31.9	48.2	69.7	52.4	-----	-----	-----	-----	-----	-----	-----	-----
1809	28.2	47.4	68.3	52.3	-----	-----	-----	-----	-----	-----	-----	-----
1810	32.4	49.0	69.5	50.8	-----	-----	-----	-----	-----	-----	-----	-----
1811	28.5	47.5	69.5	53.7	-----	-----	-----	-----	-----	-----	-----	-----
1812	27.1	42.9	67.5	49.9	-----	-----	-----	-----	-----	-----	-----	-----
1813	27.0	45.2	70.9	53.3	-----	-----	-----	-----	-----	-----	-----	-----
1814	28.2	47.3	68.5	51.0	-----	-----	-----	-----	-----	-----	-----	-----
1815	25.6	44.8	68.2	50.3	-----	-----	-----	-----	-----	-----	-----	-----
1816	26.6	43.0	65.2	51.0	-----	-----	-----	-----	-----	-----	-----	-----
1817	25.0	43.7	66.4	50.6	37.0	55.8	74.4	56.4	-----	-----	-----	-----
1818	25.4	43.7	69.0	50.7	34.5	51.8	73.0	55.8	-----	-----	-----	-----
1819	29.1	43.4	69.3	52.7	37.4	52.6	77.2	56.8	-----	-----	-----	-----
1820	27.8	44.9	69.5	50.4	35.9	54.9	75.0	53.4	-----	-----	-----	-----

[11] Figure 10. [12] Figure 11.

TABLE 3.—*Mean seasonal temperatures*—Continued

Year	New Haven, Conn.				Washington, D.C.				Iowa State			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
1821	25.9	44.3	68.9	51.1	32.9	50.9	74.4	55.7	-----	-----	-----	-----
1822	26.4	48.8	68.5	54.2	33.6	59.2	78.1	61.0	-----	-----	-----	-----
1823	26.9	46.0	70.0	48.8	38.4	58.5	75.7	54.2	-----	-----	-----	-----
1824	31.5	47.3	68.0	51.5	37.4	53.7	74.9	55.6	-----	-----	-----	-----
1825	31.9	49.1	71.7	52.2	37.9	56.3	76.5	57.1	-----	-----	-----	-----
1826	29.4	47.0	69.6	52.4	37.4	58.2	76.1	58.6	-----	-----	-----	-----
1827	27.6	47.4	67.7	51.8	36.1	57.4	76.9	57.5	-----	-----	-----	-----
1828	34.7	47.3	72.0	52.6	41.9	53.6	77.4	56.8	-----	-----	-----	-----
1829	28.3	46.3	69.2	50.1	33.7	53.9	74.1	53.9	-----	-----	-----	-----
1830	29.9	50.2	70.2	54.3	37.0	55.5	76.9	59.8	-----	-----	-----	-----
1831	27.2	50.6	72.6	52.3	30.9	54.6	73.9	54.8	-----	-----	-----	-----
1832	23.8	44.2	67.2	50.6	32.7	54.4	75.2	59.0	-----	-----	-----	-----
1833	29.3	47.4	67.3	49.4	37.1	56.2	73.8	55.0	-----	-----	-----	-----
1834	30.0	47.9	69.0	49.5	36.6	54.9	76.1	54.2	-----	-----	-----	-----
1835	25.7	44.2	68.0	50.0	31.6	53.0	75.7	56.8	-----	-----	-----	-----
1836	21.9	44.1	66.1	47.2	32.3	50.3	71.0	52.3	-----	-----	-----	-----
1837	24.8	44.8	67.0	48.4	33.4	51.8	73.3	55.4	-----	-----	-----	-----
1838	29.1	45.7	70.7	48.3	35.0	51.1	78.0	52.8	-----	-----	-----	-----
1839	27.3	48.1	68.8	50.6	33.1	55.3	71.1	54.3	-----	-----	-----	-----
1840	27.6	48.0	70.5	50.7	32.6	55.2	73.9	54.0	-----	-----	-----	-----
1841	29.0	45.7	71.6	50.3	31.7	50.1	74.1	53.6	-----	-----	-----	-----
1842	34.4	49.6	69.4	48.5	38.1	55.0	73.1	53.4	-----	-----	-----	-----
1843	25.9	46.2	68.5	48.9	34.6	46.5	75.4	55.4	-----	-----	-----	-----
1844	26.5	52.3	69.9	51.9	33.7	55.8	74.1	53.1	-----	-----	-----	-----
1845	29.4	48.7	71.4	52.7	36.2	54.1	74.9	55.7	-----	-----	-----	-----
1846	26.0	49.0	69.9	54.2	33.3	57.2	74.6	58.7	-----	-----	-----	-----
1847	28.2	45.1	70.6	51.4	36.7	53.9	73.6	56.3	-----	-----	-----	-----
1848	31.3	46.7	69.4	49.5	37.5	54.9	74.3	53.4	-----	-----	-----	-----
1849	26.9	45.6	69.8	52.6	36.8	54.5	76.1	59.1	-----	-----	-----	-----
1850	30.8	43.5	69.5	51.9	38.8	52.6	76.3	58.7	-----	-----	-----	-----
1851	29.7	47.1	68.4	52.0	40.6	56.5	74.9	57.9	-----	-----	-----	-----
1852	25.5	45.2	68.2	51.3	33.6	52.4	74.1	55.3	-----	-----	-----	-----
1853	33.1	48.0	68.3	51.5	38.0	54.5	75.7	57.1	-----	-----	-----	-----
1854	29.1	46.8	70.3	52.5	36.2	55.1	76.1	56.7	-----	-----	-----	-----
1855	27.2	46.0	68.5	51.8	31.3	53.4	74.4	57.1	-----	-----	-----	-----
1856	25.2	44.4	69.1	51.3	28.3	50.3	74.7	55.1	-----	-----	-----	-----
1857	25.9	43.2	67.0	51.3	31.6	48.1	72.7	54.6	-----	-----	-----	-----
1858	31.3	44.9	68.0	50.2	35.1	51.6	75.8	55.1	-----	-----	-----	-----
1859	29.3	47.8	66.6	49.8	38.3	55.1	73.3	55.3	-----	-----	-----	-----
1860	26.8	47.2	68.6	51.8	33.1	54.4	73.8	54.9	-----	-----	-----	-----
1861	28.3	47.0	69.4	53.4	34.8	52.5	73.1	56.9	-----	-----	-----	-----
1862	28.6	46.9	69.1	53.7	36.0	51.8	71.7	57.1	-----	-----	-----	-----
1863	31.4	45.8	70.8	52.9	36.2	50.1	73.8	54.8	-----	-----	-----	-----
1864	29.0	47.2	72.2	51.0	34.9	52.1	75.2	54.6	-----	-----	-----	-----
1865	26.4	48.6	70.4	52.4	31.9	54.9	74.8	57.6	-----	-----	-----	-----
1866	27.0	45.3	69.7	51.3	34.7	53.3	73.7	57.7	-----	-----	-----	-----
1867	25.3	45.7	69.0	50.3	32.2	50.4	73.0	57.0	-----	-----	-----	-----
1868	21.3	43.7	70.7	49.0	29.4	50.7	75.1	54.4	-----	-----	-----	-----
1869	28.7	43.7	67.3	49.7	35.8	50.7	73.9	51.9	-----	-----	-----	-----
1870	29.0	42.3	71.3	52.3	37.0	51.6	75.9	57.0	-----	-----	-----	-----
1871	25.7	44.0	71.0	51.7	34.2	56.7	74.7	54.6	-----	-----	-----	-----
1872	26.7	45.0	70.3	50.3	32.5	52.9	78.5	55.7	-----	-----	-----	-----
1873	26.5	44.7	69.7	49.5	32.0	52.8	76.6	54.6	-----	44.6	74.7	47.1
1874	30.5	43.8	69.5	53.1	39.3	52.0	76.4	56.9	21.1	45.9	74.5	49.0
1875	27.0	44.6	71.2	50.9	32.5	50.2	73.9	53.1	11.8	43.5	69.7	46.2
1876	32.2	47.2	74.2	52.2	38.1	51.8	77.2	53.7	26.3	45.5	71.7	46.2
1877	29.0	48.6	72.5	55.4	31.8	51.9	76.0	57.2	19.9	45.0	70.9	49.4

TABLE 3.—*Mean seasonal temperatures*—Continued

Year	New Haven, Conn.				Washington, D.C.				Iowa State			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
1878	34.3	51.6	71.2	55.2	38.4	56.7	74.8	57.1	32.2	50.9	72.5	50.5
1879	29.1	48.2	70.7	54.4	31.9	53.5	75.1	57.3	18.3	50.1	72.5	51.3
1880	36.1	49.9	71.7	51.9	41.3	55.9	75.3	54.3	25.2	49.3	72.4	44.7
1881	25.3	46.2	68.2	56.4	29.8	52.5	74.9	62.5	14.2	45.4	74.3	50.3
1882	32.0	44.0	69.4	52.7	38.4	51.4	74.6	57.6	30.2	46.5	69.6	51.8
1883	26.8	43.6	69.1	50.6	33.7	50.7	74.4	56.4	15.6	45.0	69.9	47.5
1884	28.2	44.9	68.1	53.7	35.7	52.5	73.6	58.7	18.8	46.1	69.9	52.1
1885	26.0	42.7	68.6	51.8	31.9	50.0	74.1	55.4	12.7	45.4	69.8	48.3
1886	28.3	46.5	67.3	53.1	32.8	53.2	72.3	57.7	18.0	47.8	73.2	50.0
1887	27.4	45.5	69.5	50.6	34.2	52.7	75.3	55.1	13.4	49.7	73.3	47.9
1888	26.9	42.9	68.7	50.2	34.0	51.0	74.1	54.9	15.3	43.7	71.9	48.2
1889	30.6	48.5	68.0	51.7	35.9	54.1	73.0	54.8	22.7	49.7	70.2	47.1
1890	36.5	45.5	67.5	51.6	44.3	52.9	74.5	57.4	26.3	45.3	71.8	49.2
1891	29.8	46.1	67.5	52.3	37.7	51.8	72.7	56.2	24.6	45.2	68.9	49.3
1892	32.4	44.8	69.8	51.1	37.3	51.0	76.1	55.1	25.2	43.8	71.2	50.8
1893	24.8	44.7	68.7	51.4	31.0	52.2	74.7	55.4	14.7	44.6	71.9	50.4
1894	29.1	48.3	69.4	51.7	37.1	55.9	75.2	57.8	20.3	51.3	74.7	49.8
1895	23.7	45.9	69.0	52.5	31.7	52.7	74.9	57.0	20.0	50.1	71.2	49.0
1896	29.6	46.5	69.0	52.7	36.3	54.6	74.6	57.5	25.4	50.3	71.5	45.3
1897	29.0	47.4	67.7	52.4	34.4	53.8	73.3	57.4	24.2	46.1	71.2	50.7
1898	31.4	47.4	69.8	53.5	36.6	54.7	76.4	57.6	21.9	48.4	72.0	48.3
1899	27.7	46.1	69.5	52.5	32.1	53.5	75.2	56.5	16.7	44.0	72.7	54.4
1900	31.1	45.8	70.7	55.8	35.0	52.5	76.8	61.5	21.0	48.7	73.5	52.4
1901	28.1	45.4	70.5	51.3	33.6	52.7	76.1	54.5	22.7	48.3	76.2	51.1
1902	28.5	48.6	67.2	54.1	32.1	55.0	73.8	58.6	20.2	50.4	69.1	51.3
1903	29.8	50.6	65.5	51.6	35.1	56.1	71.6	55.2	21.0	50.1	68.9	49.1
1904	23.7	46.2	67.9	50.0	29.4	52.3	72.6	54.9	16.1	46.2	68.9	52.7
1905	23.9	46.7	68.4	52.8	29.0	54.7	73.9	56.5	15.8	49.1	71.6	51.1
1906	33.2	46.1	70.3	54.0	37.2	52.5	74.8	59.2	25.1	46.8	71.0	51.0
1907	26.5	44.4	67.8	52.5	34.8	52.1	71.4	55.3	23.2	45.2	70.4	50.0
1908	30.7	48.6	70.5	54.6	34.4	56.4	74.3	56.9	26.0	49.3	70.0	52.8
1909	32.7	46.5	68.9	53.2	38.7	53.6	73.7	56.8	24.9	44.7	72.5	51.5
1910	29.9	49.9	69.3	53.3	33.4	56.8	73.7	57.5	17.0	52.3	72.0	50.6
1911	28.8	47.1	69.9	52.4	35.2	54.1	76.1	56.8	23.6	50.4	74.3	48.1
1912	28.6	46.9	69.1	54.9	32.3	53.9	73.2	58.9	16.7	45.8	70.6	51.5
1913	34.7	49.3	70.2	54.9	40.1	56.3	74.9	58.0	23.4	47.2	74.4	52.6
1914	30.1	47.1	68.5	54.3	36.4	53.3	75.4	57.2	25.5	48.5	74.2	53.8
1915	32.3	47.7	68.3	55.7	35.7	53.6	73.6	58.6	20.8	47.5	66.8	52.8
1916	30.1	44.9	68.7	53.9	36.4	52.7	74.2	56.5	20.6	47.4	72.7	50.2
1917	29.5	44.6	70.6	50.0	34.4	52.4	75.0	52.9	17.0	45.1	69.9	48.7
1918	23.3	49.2	69.2	53.5	29.5	57.1	74.3	57.0	15.4	50.9	73.3	51.2
1919	34.3	48.8	69.3	54.1	39.0	54.9	74.9	59.8	28.1	48.0	73.6	50.6
1920	24.9	48.5	69.0	55.0	31.3	52.7	73.8	58.6	18.6	46.6	70.8	53.2
1921	32.6	51.8	69.9	54.8	38.3	59.0	75.4	59.6	28.6	52.8	74.9	51.8
1922	29.4	49.4	69.7	54.4	36.2	55.9	74.7	59.1	23.9	50.5	72.5	55.1
1923	26.9	48.8	69.1	53.7	35.7	54.1	75.2	56.9	23.6	45.8	72.3	50.9
1924	32.3	49.4	68.9	52.3	38.1	51.5	73.7	55.9	24.4	45.5	69.6	52.0
1925	31.0	49.2	70.4	51.3	37.4	54.6	75.7	56.4	21.1	51.1	72.3	48.4
1926	30.3	44.7	68.9	52.8	35.8	52.1	74.1	57.1	25.0	47.6	71.5	48.9
1927	29.7	47.2	68.2	56.6	36.6	54.5	71.7	60.5	24.7	49.1	69.1	53.5
1928	32.4	46.1	71.3	53.9	37.5	53.0	75.4	58.1	24.2	48.6	70.4	51.1
1929	30.2	49.4	69.8	53.8	36.4	57.4	74.6	57.8	17.6	49.3	71.2	48.8
1930	32.3	48.2	71.5	54.8	38.6	55.2	77.4	59.6	23.6	49.9	73.8	52.8
1931	31.1	48.7	72.0	58.6	37.4	53.5	76.2	63.1	30.3	47.8	74.9	57.2
1932	36.7	47.3	70.8	54.3	44.6	52.3	76.1	57.7	28.5	46.9	73.3	48.3
1933	35.2	48.5	68.7	-----	40.2	55.3	75.6	-----	25.6	48.4	74.8	-----

BALTIMORE, MD., WEATHER RECORDS FOR OVER 100 YEARS

By JOHN R. WEEKS

[Weather Bureau, Baltimore, Md., Sept. 11, 1933]

A very long weather record is necessary in order to cover abnormal weather periods, and even then we cannot be sure that all extremes natural to the locality have been met.

At Baltimore observations began with 1817, and there are now nearly 117 years of record. Nevertheless, in the past 10 years have occurred the driest month (October 1924, 0.05 inch); the wettest month (August 1933, 13.83 inches); the driest year (1930, 21.55 inches); the driest autumn (1930, 1.87 inches); the warmest year (1931, 59.2°); the warmest winter (1931–32, 45.3°); the warmest autumn (1931, 64.7°); the highest May temperature (98° in 1925); the highest June temperature (101° in 1925); the highest November temperature (82° in 1929); the lowest November temperature (12° in 1929); the lowest April temperature (15° in 1925); the greatest November 24-hour rainfall (3.34 inches in 1926); the greatest August 24-hour rainfall (7.62 inches in 1933); and the greatest 24-hour rainfall of any month (7.62 inches in August 1933).

Warmest and coldest seasons; wettest and driest seasons; driest and wettest months at Baltimore, Md., 1817–1933

Season	Warm		Cold		Wet		Dry	
	Average	Date	Average	Date	Total	Date	Total	Date
Winter	45.3	1931–32	29.3	1917–18	18.45	1858–59	3.80	1864–65
	44.5	1889–90	29.7	1903–04	15.90	1914–15	3.97	1870–71
	43.3	1827–28	29.9	1904–05	15.41	1880–81	4.24	1871–72
	41.4	1879–80	30.7	1892–93	15.01	1881–82	4.33	1829–30
	41.0	1850–51	31.4	1835–36	14.90	1902–03	4.90	1847–48
	40.4	1869–70	31.5	1919–20	14.80	1901–02	5.12	1863–64
	40.4	1857–58	31.6	1866–67	14.48	1883–84	5.17	1900–01
	40.4	1824–25	31.6	1880–81	14.45	1823–24	5.20	1818–19
Normal	36.0		36.0		9.70		9.70	
Spring	59.2	1869	44.8	1843	21.23	1889	3.98	1847
	59.1	1922	48.8	1841	17.60	1839	4.10	1855
	58.8	1921	50.2	1836	17.23	1924	4.16	1866
	58.4	1826	50.7	1874	17.10	1854	5.14	1856
	57.7	1827	50.7	1857	16.90	1829	5.52	1869
	57.3	1929	50.8	1892	16.70	1892	5.55	1845
	57.3	1871	50.8	1863	16.14	1863	5.62	1915
	57.0	1831	50.3	1875	16.01	1910	5.89	1827
Normal	53.8		53.8		10.63		10.63	

Warmest and coldest seasons; wettest and driest seasons; driest and wettest months at Baltimore, Md., 1817–1933—Continued

Season	Warm		Cold		Wet		Dry	
	Average	Date	Average	Date	Total	Date	Total	Date
Summer	81.0	1870		1816	23.00	1817	2.56	1869
	78.8	1868	71.6	1836	22.66	1920	3.59	1864
	78.7	1822	72.1	1903	21.61	1933	4.39	1930
	78.7	1872	72.3	1907	21.33	1911	5.40	1870
	78.6	1838	72.5	1927	18.66	1906	5.91	1841
	78.4	1828	72.5	1891	18.60	1889	5.95	1893
	78.1	1930	73.2	1886	18.54	1903	6.55	1909
	78.0	1900	73.2	1862	18.54	1904	6.57	1866
Normal	75.6		75.6		11.96		11.96	
Fall	64.7	1931	53.1	1836	19.70	1821	1.87	1930
	63.3	1881	53.5	1838	18.50	1854	4.58	1825
	61.8	1900	53.8	1844	17.75	1902	4.60	1884
	61.6	1822	53.9	1917	17.34	1877	4.77	1879
	61.2	1855	54.1	1842	16.72	1843	4.80	1819
	61.1	1927	54.2	1876	16.05	1876	4.79	1931
	61.1	1830	54.3	1875	15.16	1889	5.04	1870
	60.4	1854	54.4	1873	15.15	1907	5.05	1863
Normal	57.3		57.3		9.14		9.14	
Years	59.2	1931	51.8	1836	62.35	1889	21.55	1930
	58.8	1822	52.6	1904	59.20	1854	22.43	1870
	58.5	1870	52.9	1841	55.64	1859	22.87	1856
	58.5	1826	53.4	1917	54.62	1836	23.02	1864
	58.4	1827	53.6	1907	54.21	1891	26.25	1825
	58.2	1921	53.6	1863	52.26	1829	27.34	1869
	58.2	1865	53.6	1893	52.11	1886	27.48	1866
	58.2	1828	53.7	1862	51.70	1839	28.39	1845
Normal	55.6		55.6		42.09		42.09	

Driest months			Wettest months		
Month	Year	Amount	Month	Year	Amount
October	1924	0.05	August	1933	13.83
September	1884	.09	August	1911	12.28
February	1864	.14	July	1889	11.03
May	1866	.20	September	1821	10.70
May	1826	.21	July	1905	10.65
July	1869	.30	September	1876	10.52
November	1870	.28	September	1843	10.50
July	1870	.35	August	1817	10.40
December	1896	.37	August	1873	9.49

THE NORTH ATLANTIC TRADE WINDS

By C. L. RAY

[Weather Bureau Office, San Juan, P.R., Sept. 30, 1933]

The fact that the area of the trade-wind belt of the North Atlantic is estimated to be 10 million square miles suggests the impracticability of attempting a detailed study of the wind data over the entire region. In the monthly Pilot Charts of the United States Hydrographic Office of the Navy we have a complete set of monthly averages of these winds. Their percentages, including calms, velocities in terms of the Beaufort scale and prevailing directions, within the 8 points of the compass, are given for each 5° of latitude by 5° of longitude. Observations from transatlantic and coastwise ships contributed largely, and continue to do so, to the comprehensive mapping of ocean areas. On the other hand, we lack comparative data for different years, at least in assembled form. The present paper gives a more or less detailed arrangement of the wind data by months and years for one station (San Juan, Puerto Rico) in the trade-wind belt. It includes the variations from year to year in total wind movement; treats of the "trades" as a separate entity; gives the wind velocities and notes the percentage of winds from the east, northeast and southeast. These data also are compared with their normal or average values.

Beals [1] has given an interesting survey of "The Northeast Trades of the North Pacific" from which suggestions have been obtained for the present paper. In referring to the general world pressure system, the following is quoted as applying with equal force to both areas:

> The chief features of world pressure distribution are (1) an equatorial belt or zone of diminished pressure, (2) another of high pressure around the world about 30° north and south of the Equator, and (3) other belts of low pressure about latitude 60° north and south. The high-pressure belts about 30° from the Equator are not continuous around the world but form a series of well-known semipermanent anticyclones, each with its appropriate wind system. The most prominent semipermanent anticyclones in the Northern Hemisphere are the great Siberian anticyclone of winter, and winter only, and the two oceanic anticyclones—the the Azores in the Atlantic and the North Pacific in the ocean of that name. * * * These cyclones and anticyclones must not be confused with the traveling cyclones and anticylones of the daily weather maps. The latter preserve their form and travel in a definite direction over the earth's surface for a time. The former, on the other hand, must not be thought of as having [in any case] a distinct entity which is continuously preserved.

The Azores HIGH, associated with the trade-wind system of the North Atlantic area, attains its greatest extent and force in June and July, with a maximum pressure of 30.25 inches, gradually diminishes during the fall months to a minimum pressure of 30.10 inches in October. In July it extends from latitude 30° N. to 40° N. and longitude 20° W. to 50° W. The wind circulation about the Azores anticyclone is clockwise in direction, northeast predominating in the eastern half of the area, becoming east-northeast to east, with diminishing latitude and east and southeast near the Equator and north of the West Indies under the influence of the southerly circulation in the left half of the formation. Farther north in latitude 35° to 50°, winds become southwesterly. The mean position of the center of this anticyclone shifts somewhat from month to month, reaching in July to approximately 35° N. latitude and 35° W. longitude. In September it is at 30° W. longitude and in December at latitude 35° N., longitude 20° W. Its most southerly position is reached in January, 28° N. at longitude 39° W. The wind velocity over this area is indicated on the pilot charts generally as force 4 of the Beaufort scale (approximately 20 miles per hour). This velocity pertains to all winds having an easterly component except in October and November when it is slightly less. In addition to the above charts there are available daily records from few island and coast stations of the Atlantic and adjacent coasts.

San Juan, latitude 18°29′N., longitude 66°78′W., lies on the north coast of Puerto Rico, 53 feet above sea level, in the south and west portions of the Azores anticyclone area. The prevailing direction of the wind at the station is between east and southeast, and varies with the season and the hour of the day. The anemometer and wind vane are located on a 50-foot steel tower. The exposure to northeast and east winds is excellent. In December and January a somewhat greater amount of northeast wind than southeast is recorded, with the prevailing direction easterly as other parts of the year. A less-satisfactory exposure is afforded to the winds from the southeast, owing to the interference of mountains in the east interior of the island, to the southwest of the station. The velocities of winds from the southeast, as recorded at the station, are noticeably lower than those of northeasterly and easterly direction, although Pilot Charts for the same area, but representing open sea exposure, show equal force from all winds that have an easterly component, whether northeast, east, or southeast. These have an average force of Beaufort 4, compared with a force of 2 to 3 for southeast winds at the Weather Bureau exposure. Another disturbing factor in connection with station velocities from the southeast is the land breeze from the south and southeast, comprising a considerable portion of the wind movement at night, which though distinct from the trade-wind circulation cannot be separated from it.

In tables 1 and 2 are shown the percentages of winds recorded from the several points of the compass, and also the percentages of northeast, east, and southeast winds for each month, considered as a group. In table 3 the same data are presented in greater detail, and in table 4 a grouping by 5-year periods is made. A change in the direction of the "trades" will be noted for the last 10-year period, 1920–29, indicated by a marked increase in easterly movement with concurrent decrease in the northeast and southeast winds. This is clearly shown in the following table:

	Percentage of winds from—			
	Northeast	East	Southeast	South
1905–20	20	35	26	10
1921–29	6	55	16	15
Entire period, 1905–29	15	44	23	12

A similar shift from the existing normal direction occurred in the North Pacific area at approximately the same period, as discussed by Mr. Beales (see earlier reference). The 5-year average at Honolulu, included as part of table 4, does not fully indicate the extent of the change, which beginning in 1922, showed an increase of 200 percent in the easterly movement at the expense of northeasterly winds. Quoting Mr. Beals in this connection:

> Following a change in exposure of the wind instruments in 1922 [at Honolulu] the average [of east winds] was a little more than

[1] Beals, Edward A., Mo. Wea. Rev., May 1927, vol. 55, p. 211.

tripled, thus one can hardly escape the conclusion that the influence of an unknown factor, which probably existed before the change in exposure, was greatly increased by the change. It is nevertheless possible that a progressive although slight change in the average track of anticyclones in the North Pacific may have caused the change in wind direction under consideration. There is, however, no readily available information as to the track pursued by anticyclones for the years in question.

The analogous condition found at San Juan for the same period, and continuing for another 5-year period thereafter (no data are at hand for the latter years at Honolulu) would seem to indicate that the course of the anticyclone movement has possibly undergone a slight shift to the northward in the North Atlantic. That such a shift has taken place is indicated, but not proved, by the slightly higher pressure—for the year—at Horta, Azores Islands, since 1920. Horta, though within the central area of high pressure in June and July, is normally slightly north of the center. A shift of the track to the north would therefore, of course, be accompanied by higher readings at that station. However this would not take account of regular changes in the strength of the HIGH, which may explain the increase in pressure at Horta observed in this period. Northeast

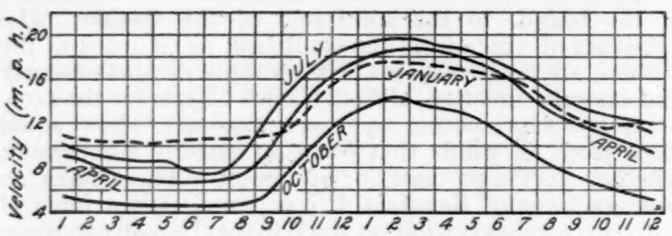


FIGURE 1. Diurnal velocity of winds, San Juan, P.R.

winds, as a rule, attain their greatest frequency at San Juan during January, when the continental high pressure area, central in the North American interior, normally extends its influence eastward, off the southeast United States coast. In this connection, a correlation of the January pressure at Nassau, Bahama Islands, with the northeast wind frequency at San Juan, indicates an apparent relation between the strength of the pressure at that station and the increased northeast movement at San Juan. Average pressure at Nassau for the period between 1921 and 1929 is, however, not immediately available for reference, so that it has not been possible to continue the comparison through the years in question. The above relationship does not appear to hold for other months but relates only to the pressure distribution obtaining during the month of January.

In table 5 is given the total monthly and annual wind movement in miles, and in table 6 the same data for NE., E., and SE. winds. The greatest mileage for all directions, and also for NE., E., and SE. winds, as a group, occurs in July, when the North Atlantic anticyclone is in greatest ascendency. The average hourly velocity is slightly greater in January for all directions, owing to the occurrence of considerable strong north and northwest winds, which are absent during the summer. In table 7 is given the monthly and annual percentage of the normal movement of wind from the NE., E., and SE., by years from 1905–29. In January 1916 the "trades" were 76 percent above normal; in January 1909 they were 47 percent below normal. In July 1917 they were 40 percent above normal; in July 1916, 26 percent below the average. For the year 1922 the annual movement of the "trades" at San Juan was 20 percent above normal; in 1912, 15 percent below the average.

As stated earlier these trade winds show, for open sea exposure, an average velocity of about 20 miles per hour for winds with an easterly component. The diurnal variation in wind velocities at the station is shown in Fig. 1. Lighter winds prevail during the night, with velocities increasing between 8 a.m. and 3 p.m.

Calms are infrequent in the zone embracing the West Indies. Over the North Atlantic as a whole we find several sections, comparatively small in extent, where little or no wind movement occurs for considerable periods. The "doldrums" are a well-defined quiet area, central at approximately 5° to 10° N. latitude in September. This region is of interest as the breeding locus of the tropical hurricane of late summer and autumn, of greatest frequency in September and August. To the westward, another, though smaller, area of calms is located in the west Caribbean and Gulf of Mexico, longitude 80° to 90° W. from which may form the southwest Caribbean hurricane, frequent in the latter half of September. In the north a third quiet area at approximately latitude 25° to 35° N. between longitude 20° to 50° W. is in the central portion of the Azores anticyclone.

The depth of the trade winds at San Juan and at Honolulu have been previously referred to in the MONTHLY WEATHER REVIEW.[1] These several studies indicate the vertical extent of the easterly winds at between 5,000 and 6,000 meters on the average, varying with the season. They are highest in the summer under the influence of strong convection. Tables 10 and 11 give the percentage of directions for the several levels by seasons and the years, with velocities in meters per second. Approximate equivalents in miles per hour may be derived by multiplying the number of meters per second by 2.2. Upper-air velocities of the "trades" probably do not depart greatly from the averages for all velocities combined—shown in the table—at least through the 6-kilometer level. Above that level observations become fewer in number and the directions more variable if not predominantly from some westerly point.

TABLE 1.—*Percentage of NE., E., and SE. winds for each month of the year, San Juan, P.R.*

Month	Percent	Month	Percent
January	83.6	July	93.0
February	79.2	August	89.3
March	78.2	September	74.3
April	82.9	October	66.0
May	83.5	November	70.0
June	91.8	December	79.1

TABLE 2.—*Percentage of winds from the eight points of the compass—monthly and annual*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	2.2	20.5	45.4	17.7	9.2	3.4	0.6	1.0
February	2.5	18.2	41.6	19.4	11.2	5.5	0.5	1.1
March	3.7	18.9	40.4	18.9	11.4	3.8	0.9	2.0
April	1.6	19.8	41.6	21.5	11.4	2.7	0.7	0.7
May	1.1	11.8	43.8	27.9	12.6	1.8	0.5	0.5
June	0.2	7.5	55.3	29.0	7.0	0.6	0.3	0.1
July	0.2	9.0	61.8	22.2	5.9	0.8	0.1	0.0
August	0.6	12.9	54.6	21.8	8.3	1.2	0.3	0.3
September	1.4	11.9	35.3	27.1	17.9	4.4	1.2	0.8
October	1.3	10.5	29.2	26.3	24.2	6.3	1.2	1.0
November	2.5	17.9	30.2	21.9	18.4	6.2	1.4	1.5
December	3.5	20.2	40.7	18.2	11.1	4.2	1.0	1.1
Annual	1.4	14.9	43.7	22.7	12.4	3.4	0.7	0.8

[1] Beals, E. A. Free-air winds over Honolulu and Guam. May 1927, vol. 55, pp. 222-226; Fassig, O. L. Pilot-balloon observations at San Juan, P.R. January 1924, vol. 52, pp. 22–26; Ray, C. L. Free-air winds at San Juan, P.R. November 1931, vol. 49, 414–416; Fassig. O. L. The trade winds in Puerto Rico. May 1911, vol. 39, pp. 796–799.

TABLE 3.—*Number of hours each year the wind at San Juan was NE., E., and SE., 1905–29, inclusive*

Year	Number of hours from—				Percent from—		
	NE.	E.	SE.	NE.-E. SE.	NE.	E.	SE.
1905	610	3,823	2,720	7,153	7	44	31
1906	1,435	3,708	2,101	7,244	17	42	24
1907	1,565	3,819	1,826	7,210	18	44	21
1908	1,173	3,266	2,801	7,240	13	37	32
1909	1,431	3,016	2,749	7,196	16	34	31
1910	1,949	3,320	1,911	7,180	22	38	22
1911	1,661	3,199	2,423	7,283	19	37	28
1912	984	3,498	2,859	7,341	11	40	33
1913	2,216	3,285	2,261	7,762	25	38	26
1914	1,823	2,724	2,609	7,156	21	32	30
1915	2,224	2,426	2,048	6,698	25	28	23
1916	2,651	2,535	2,396	7,582	30	29	27
1917	2,841	2,426	1,822	7,089	32	28	21
1918	2,177	2,983	1,978	7,138	25	34	23
1919	2,071	2,627	2,045	6,743	24	30	23
1920	1,227	4,071	2,187	7,485	14	47	25
1921	355	4,498	1,259	6,112	5	51	14
1922	572	5,391	991	6,954	7	62	11
1923	416	4,905	1,226	6,547	5	56	14
1924	390	4,696	1,721	6,807	4	54	20
1925	452	4,464	1,696	6,612	5	51	19
1926	554	4,551	1,669	6,774	6	52	19
1927	901	4,780	1,103	6,784	10	55	13
1928	550	5,405	1,657	7,612	6	62	19
1929	310	5,629	1,589	7,528	4	64	18
Total	32,538	95,045	49,647	177,230	371	1,089	567
Average	1,301.5	3,801.8	1,985.9	7,093.2	15	44	23

TABLE 4.—*5-year average annual of NE., E., and SE. winds at San Juan, P.R., 1905–29, inclusive*

	San Juan, P.R.			Honolulu	
	NE.	E.	SE.	NE.	E.
1905–09	1,243	3,526	2,439	4,840	2,271
1910–14	1,726	3,205	2,413	4,678	2,493
1915–19	2,393	2,599	2,058	4,211	2,951
1920–24	588	4,712	1,477	4,929	4,303
1925–29	553	4,966	1,543	------	------

TABLE 5.—*Total monthly and annul wind movement in miles at San Juan, P.R., period 1905–29, inclusive*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1905	7,983	7,990	7,398	8,685	9,348	8,692	9,149	8,683	6,151	6,359	5,726	8,004	94,168
1906	8,135	5,976	8,059	8,635	9,169	8,752	9,525	9,005	7,356	6,860	9,211	10,761	101,444
1907	10,512	6,347	8,434	7,663	8,633	8,518	10,035	8,901	7,173	5,617	5,664	7,819	95,316
1908	6,494	6,960	10,464	8,917	8,069	7,882	8,140	7,648	8,000	6,188	6,410	8,807	93,979
1909	6,701	8,683	7,747	9,326	8,105	8,851	9,243	8,142	5,919	6,818	7,457	6,040	93,032
1910	9,411	9,630	7,871	7,846	8,705	9,827	9,934	9,420	7,363	5,670	4,674	6,903	97,254
1911	11,049	7,223	7,592	8,223	7,128	9,428	7,930	8,070	6,466	4,766	5,697	6,971	90,543
1912	7,229	6,362	8,145	7,437	8,115	8,521	8,785	8,241	4,904	5,572	5,647	7,384	86,342
1913	13,873	7,739	13,234	9,369	9,432	10,185	10,430	9,820	6,496	5,666	9,813	7,290	113,347
1914	7,865	9,134	8,750	8,932	8,924	9,794	11,352	10,312	8,294	5,843	4,939	8,017	102,156
1915	8,739	7,553	7,284	11,733	9,280	9,474	11,191	9,687	6,250	6,043	9,038	10,363	106,635
1916	16,438	9,312	10,092	9,316	8,202	6,509	8,228	10,922	5,958	6,934	9,219	11,353	112,483
1917	11,639	9,763	13,064	8,380	7,971	8,543	13,954	10,132	8,303	6,499	8,437	9,363	116,048
1918	9,223	11,573	9,737	9,413	11,953	8,697	10,791	10,100	7,179	6,462	6,109	9,143	110,380
1919	7,284	7,033	10,879	10,150	10,711	7,341	9,182	11,660	6,633	8,362	6,230	8,479	107,944
1920	12,370	6,677	9,810	8,382	8,505	8,470	13,695	10,450	8,146	5,789	7,280	8,588	108,162
1921	10,460	6,993	13,822	10,246	8,391	8,190	10,079	10,764	6,432	6,980	8,164	7,485	108,006
1922	10,865	12,072	13,572	11,346	9,569	9,429	11,431	9,587	8,292	5,807	7,991	12,257	122,218
1923	11,910	11,078	13,461	8,065	8,020	10,028	10,010	10,834	7,504	5,877	5,481	11,728	112,996
1924	11,325	9,342	7,451	7,719	7,736	9,199	12,762	9,785	6,661	6,730	6,419	11,768	106,897
1925	9,825	6,916	10,489	6,969	8,581	9,093	8,774	9,986	7,113	7,345	7,066	6,831	98,988
1926	8,999	7,941	8,129	8,721	7,297	9,043	9,383	8,477	6,261	6,256	7,296	11,009	98,812
1927	11,058	9,343	8,244	10,114	9,687	9,709	8,973	7,950	6,096	6,181	9,778	10,864	107,997
1928	10,332	8,273	8,899	9,597	7,023	9,066	9,488	7,693	8,607	6,186	6,154	8,609	99,927
1929	9,502	7,628	10,073	8,893	9,961	8,739	11,165	8,741	5,787	6,341	8,329	9,271	104,430
Means	9,969	8,262	9,708	8,963	8,741	8,879	10,145	9,400	6,934	6,286	7,129	9,004	103,420

Years 1928–29 from 3-cup anemometer.

TABLE 6.—*Total monthly and annual movement in miles for NE., E., and SE. winds only, at San Juan, P.R., 1905–29*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1905	6,922	7,568	6,399	7,873	9,015	8,603	8,912	8,456	5,111	5,066	4,868	7,581	86,364
1906	7,507	4,913	7,492	7,860	8,668	8,669	9,390	8,820	5,225	5,595	8,664	9,191	91,994
1907	10,261	5,921	6,557	6,605	8,141	8,127	9,949	8,698	6,824	4,364	4,891	7,519	87,857
1908	5,775	6,344	8,689	8,835	7,741	7,706	7,808	7,233	7,406	4,910	5,795	7,609	85,751
1909	4,926	8,476	6,738	9,044	7,784	8,761	9,181	7,645	5,404	5,991	4,895	4,880	84,725
1910	8,631	8,921	6,722	7,035	8,582	9,777	9,900	9,324	7,098	4,750	3,432	6,340	90,512
1911	10,856	6,466	7,003	7,846	6,556	9,346	7,678	7,810	6,087	3,551	5,008	6,463	84,730
1912	6,884	5,531	7,912	6,937	7,707	8,448	8,696	8,127	3,803	4,462	9,955	7,017	80,479
1913	13,822	7,020	13,208	8,694	8,528	10,155	10,387	9,714	6,031	4,515	9,546	6,364	107,984
1914	6,320	7,546	7,299	8,703	8,121	9,678	11,335	10,277	8,057	4,760	3,146	7,211	92,453
1915	8,030	6,976	5,051	10,985	8,913	9,224	11,064	8,000	5,077	4,647	7,812	9,529	94,390
1916	16,315	6,708	8,828	9,026	7,649	5,797	7,355	10,788	4,914	5,659	8,931	11,082	105,052
1917	11,260	8,857	12,838	7,727	7,002	8,284	13,889	9,852	7,715	5,457	7,052	7,352	107,385
1918	7,543	10,939	8,968	8,913	11,748	8,532	10,515	9,697	6,257	5,559	4,854	8,583	102,108
1919	6,377	5,769	9,682	8,934	10,079	6,830	8,563	11,455	5,011	7,839	4,161	7,378	92,078
1920	11,656	5,918	9,266	7,738	7,342	8,265	13,628	10,093	7,743	4,513	6,583	7,962	100,707
1921	9,520	5,454	13,129	9,449	6,464	6,546	9,819	10,352	4,836	5,200	7,046	5,897	93,712
1922	9,808	11,683	12,889	10,891	10,006	9,039	11,251	9,049	7,205	3,733	6,692	11,574	112,914
1923	11,336	9,761	12,938	7,165	6,031	9,754	9,716	10,462	6,558	4,001	3,294	10,412	101,368
1924	10,927	8,230	4,740	6,449	6,625	8,838	12,638	9,324	5,175	5,236	5,431	11,760	94,373
1925	9,815	5,640	7,296	4,544	7,436	8,632	8,286	9,776	6,048	6,585	5,753	5,624	85,435
1926	8,431	7,088	6,859	8,225	5,795	8,791	8,984	9,522	4,876	5,522	6,430	10,220	88,080
1927	10,368	8,775	7,100	9,441	9,228	9,466	8,363	7,046	4,864	4,495	8,383	8,291	95,820
1928	10,080	7,992	8,170	9,530	5,423	8,874	9,204	7,182	8,322	5,482	5,065	8,064	93,388
1929	8,788	7,154	9,542	7,824	9,702	8,383	11,110	8,511	4,722	5,599	7,839	9,040	98,214
Means	9,286	7,467	8,613	8,251	7,975	8,581	9,905	8,982	6,001	5,074	6,023	8,158	94,316

Years 1928–29 from 3-cup anemometer.

TABLE 7.—*Monthly and annual percentage of the normal movement of the wind from NE., E., and SE. at San Juan, P.R., 1905–29*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1905	75	101	74	95	113	100	90	94	85	100	81	93	92
1906	81	66	87	95	109	101	95	98	93	110	144	113	98
1907	111	79	76	80	102	95	100	97	73	86	82	92	93
1908	62	84	101	107	97	90	79	80	82	96	96	93	90
1909	53	114	78	110	97	102	93	85	99	117	82	60	90
1910	93	119	78	89	108	114	100	104	82	93	57	78	96
1911	117	87	81	95	82	109	77	87	59	70	84	79	90
1912	74	74	119	84	97	98	88	90	74	87	83	86	85
1913	149	94	153	105	107	118	105	108	75	88	159	78	115
1914	68	101	85	105	102	113	114	114	79	93	52	88	98
1915	86	81	59	133	112	107	112	89	77	91	130	117	101
1916	176	117	103	109	96	68	74	120	94	111	149	136	111
1917	121	118	149	94	88	97	140	109	91	107	118	90	114
1918	81	147	104	108	147	99	106	108	93	109	81	105	108
1919	69	77	112	108	126	80	86	127	131	154	69	90	98
1920	126	80	108	94	92	96	138	112	75	88	110	98	107
1921	103	73	152	115	81	76	99	115	87	102	117	72	99
1922	106	157	150	132	114	105	114	101	62	73	112	142	120
1923	122	130	150	87	76	114	98	115	67	80	55	128	108
1924	118	110	55	78	83	103	128	93	86	103	91	144	100
1925	106	74	85	55	93	101	84	109	101	129	96	69	91
1926	91	95	80	100	73	102	91	87	75	96	107	125	93
1927	112	118	82	114	116	110	84	78	82	88	140	102	102
1928	109	107	95	116	68	103	93	80	139	107	84	99	99
1929	95	96	111	95	122	99	112	95	79	110	130	111	104

TABLE 8.—*Percentage of winds with easterly component at San Juan, P.R. (upper air)*

Elevation	1 km	2 km	4 km	6 km	8 km	10 km
Spring	100	93	63	33	13	1
Summer	97	95	84	63	28	31
Autumn	89	81	56	42	33	27
Winter	96	86	61	45	22	4
Annual	94	86	66	47	29	21

TABLE 9.—*Velocities in meters per second, at San Juan, P.R. (upper air)*

Elevation	1 km	2 km	4 km	6 km	8 km	10 km
Spring	9.2	6.1	4.9	6.6	10.9	18.0
Summer	8.7	7.4	5.3	4.8	6.1	8.1
Autumn	5.9	5.0	4.1	4.8	6.6	9.5
Winter	7.9	6.0	5.0	7.2	9.4	17.0
Annual	7.4	6.0	4.7	5.2	7.2	10.7

THE TEMPERATURE RELATIONS BETWEEN WATER AND AIR AT SAINT ANDREWS, N.B.

By H. B. HACHEY

[Atlantic Biological Station, Saint Andrews, N.B., August 1933]

INTRODUCTION

One phase of the hydrographic investigations carried out by the Biological Board of Canada requires the recording of water temperatures throughout the year at various points on the Canadian Atlantic coast. In this connection water and air temperatures have been recorded at Saint Andrews, N.B., for several years past. The records for the period 1921–29, inclusive, have been analyzed and form the subject matter of this paper.

Collection and compilation of data.—The water temperatures were determined twice daily from the end of the pier at the Atlantic Biological Station, usually at 8 a.m. and 5 p.m. The depth of water at the end of the pier varies from approximately 10 feet (3.0 m) to 35 feet (10.6 m), depending upon the time and amplitude of the tide. Maximum and minimum air temperatures were obtained daily by means of a thermometer situated about 20 feet (6.1 m) from high-water mark and about 10 feet (3.0 m) above high-water level.

From the recorded data for the period 1921–29, inclusive, monthly normals for water and air have been determined and are recorded in table 1 and plotted in figure 1.

Analysis of data.—Sine curves were found to fit the plotted data quite closely. The equations representing these curves are as follows:

$$\text{Water, } y_1 = 6.2 - 6.2 \sin \frac{\pi(x+2)}{6} \qquad (1)$$

$$\text{Air, } y_2 = 6.0 - 12.4 \sin \frac{\pi(x+3)}{6} \qquad (2)$$

where

y_1 = normal water temperature in degrees centigrade.
y_2 = normal air temperature in degrees centigrade.
and x = time expressed in months.

Values of y_1 and y_2 calculated afrom the above equations are given in table 1.

According to equations (1) and (2) we have the following results:

1. Normally, the maximum daily mean air temperature is reached on July 15, and the maximum daily mean water temperature is reached on August 15.

2. Normally, the minimum daily mean air temperature is reached on January 15, and the minimum daily mean water temperature is reached on February 15.

It is thus shown that in the Saint Andrews region the water temperatures lag behind the air temperatures by approximately 1 month.

Combining equations (1) and (2), we may write

$$y_3 = y_1 - y_2 = .2 - 3.1 \sin \frac{\pi x}{6} + 7.0 \cos \frac{\pi x}{6} \qquad (3)$$

where y_3 is the difference between the normal water temperatures and the normal air temperatures, equation (3) is also plotted in figure 1, and the calculated values of y_3 are recorded in table 2.

By means of a simple analysis of the equation for y_3 the following results are obtained:

1. The greatest numerical values of y_3 are found to be
$y_3 = 7.7$ at $x = 5.2$ .... June 21.
$y_3 = 7.9$ at $x = 11.2$ .... Dec. 21–22.
2. Similarly
$y_3 = 0.0$ at $x = 2.2$ .... Mar. 21–22.
and at $x = 8.2$ .... Sept. 21.
3. The average positive value of y_3 is 5.0, and the average negative value of y_3 is 4.7.

Limitations of the formula.—The value of the analysis of the various formulae is limited for the following reasons:

(*a*) The normals have been derived from data obtained over a comparatively short period. The taking of air temperatures has suffered some short interruptions.

(*b*) The variation between the normals derived from the observed data and those derived by means of the formula may be as large as 3.3°.

(*c*) It is possible to determine sine curves which will fit the observed values with greater accuracy. To do this it would be necessary to determine weekly normals. This would result in an increased amplitude and a slight change in the factor determining the phase.

Discussion.—The annual movements of the sun with reference to some fixed point on the earth being truly periodic, various periodic effects are produced. Atmospheric conditions remaining constant, a determination of the intensity of radiation falling daily on a chosen area would show a variation following a periodic law. In such a case a very shallow body of water would exhibit a similar periodic variation in temperature. If the depth of the water was considerable a pronounced lag in the water temperatures would be noted.

In the practical case, atmospheric conditions are anything but constant, and the various bodies of water that concern us are usually subjected to agencies other than direct heat from the sun which tend to determine the temperatures of the surface waters. To illustrate, various waters are frozen over throughout several months of the year with the result that the upper layers of the water have about the same temperature throughout the period of ice. Other waters are subjected to the influence of waters of very pronounced currents which may supply varying amounts of either warm water, or cold water containing much drift ice or icebergs. The surface temperatures of water areas comparatively free from such influences would, however, follow a periodic law.

Similarly, if the air temperatures in a given region were determined solely by direct heat from the sun, the mean daily temperatures would follow a periodic law. Various factors other than direct heat from the sun, particularly air movements, atmospheric conditions, and conditions on the earth's surface, enter to determine the air temperatures in a given locality and consequently a periodic variation is only approximated.

The temperatures of the surface waters in the St. Andrews region are peculiar to the region. A large body of water is concerned with tidal effects which bring about an interchange of surface and bottom water on a large scale. This volume action is responsible for the storing of heat absorbed, and for the releasing of heat when a transference from water to air can take place. That this storing of heat does take place on a large scale is shown by the marked lag of the water temperatures behind those of the air.

The interchange of heat between the air and the water would be controlled by a number of factors. Definitely the temperature gradient would play a large part in determining the magnitude and the direction of the interchange. For this reason it is of interest to note the times of the year when the temperature gradient normally has its maximum and minimum values. The position of the sun with reference to the earth's equator at the times of maximum and minimum values of the temperature gradient is also worthy of note.

The average positive value of the temperature gradient is approximately equal to the average negative value. Hence, insofar as the temperature gradient is concerned, the influence of the water on the air in this region must be approximately the same as the influence of the air on the water.

SUMMARY

1. The normal temperature of the water at St. Andrews, New Brunswick, at any time can be represented by a formula of the form

$$y_1 = 6.2 - 6.2 \sin \frac{\pi(x+2)}{6}$$

where y_1 is the temperature in degrees centigrade, and x is the time in months.

2. The normal temperature of the air at St. Andrews, New Brunswick, at any time can be represented by a formula of the form

$$y_2 = 6.0 - 12.4 \sin \frac{\pi(x+3)}{6}$$

where y_2 is the temperature in degrees centigrade, and x is the time in months.

3. The relation between the water and air normal temperatures at St. Andrews, New Brunswick, can be represented by a formula of the form

$$y_3 = 0.2 - 3.1 \sin \frac{\pi x}{6} + 7.0 \cos \frac{\pi x}{6}$$

where $y_3 = y_1 - y_2$.

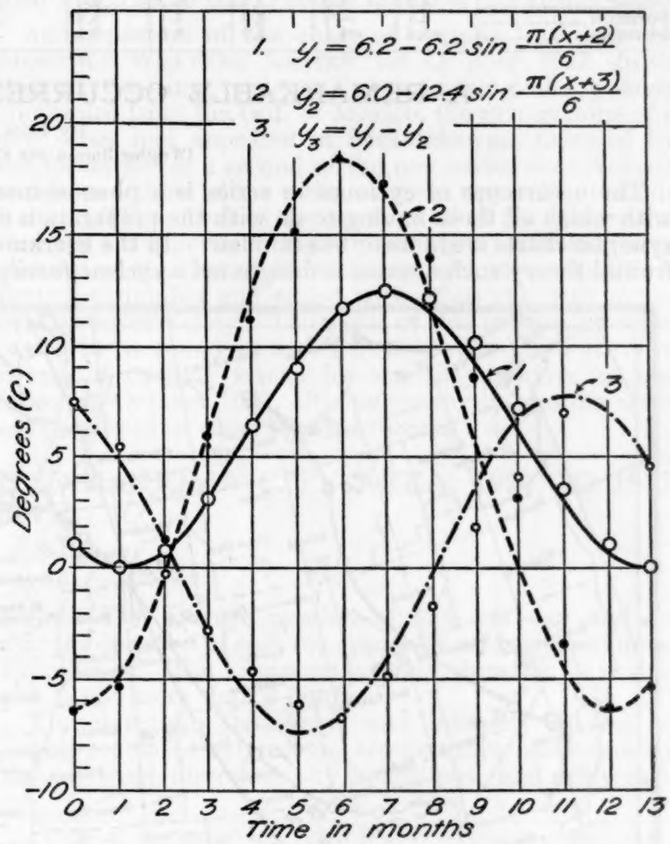


FIGURE 1.

4. On July 15 the maximum temperature of the air is normally reached.

5. On August 15 the water normally reaches its maximum temperature.

6. On January 15 the minimum temperature of the air is normally reached.

7. On February 15 the water normally reaches its minimum temperature.

8. On June 21 y_3 normally has its greatest negative value, i.e., the temperature gradient between the air and the water has reached its greatest positive value.

9. On March 21 y_3 is normally equal to zero, i.e., the temperature gradient between the air and the water is zero.

10. On September 21 y_3 is normally equal to zero, i.e., the temperature gradient between the air and the water is again zero.

11. On December 21 y_3 normally has its greatest positive value, i.e., the temperature gradient between the air and the water has reached its greatest negative value.

12. The average positive value of y_3 is normally 5.0, and the average negative value of y_3 is normally 4.7.

TABLE 1

Month	Air normals			Water normals		
	Observed values	Calculated from equation	Difference	Observed values	Calculated from equation	Difference
	(a)	(b)	(a-b)	(c)	(d)	(c-d)
January	−6.4	−6.4	0.0	1.0	0.8	0.2
February	−5.4	−4.7	−.7	.0	.0	.0
March	1.1	−.2	1.3	.9	.8	.1
April	5.9	6.0	−.1	3.1	3.1	.0
May	11.2	12.2	−1.0	6.5	6.2	.3
June	15.1	16.7	−1.6	8.9	9.3	−.4
July	18.4	18.4	.0	11.6	11.6	.0
August	17.3	16.7	.6	12.4	12.4	.0
September	13.9	12.2	1.7	12.1	11.6	.5
October	8.5	6.0	2.5	10.2	9.3	.9
November	3.1	−.2	3.3	7.1	6.2	.9
December	−3.4	−4.7	1.3	3.5	3.1	.4

TABLE 2

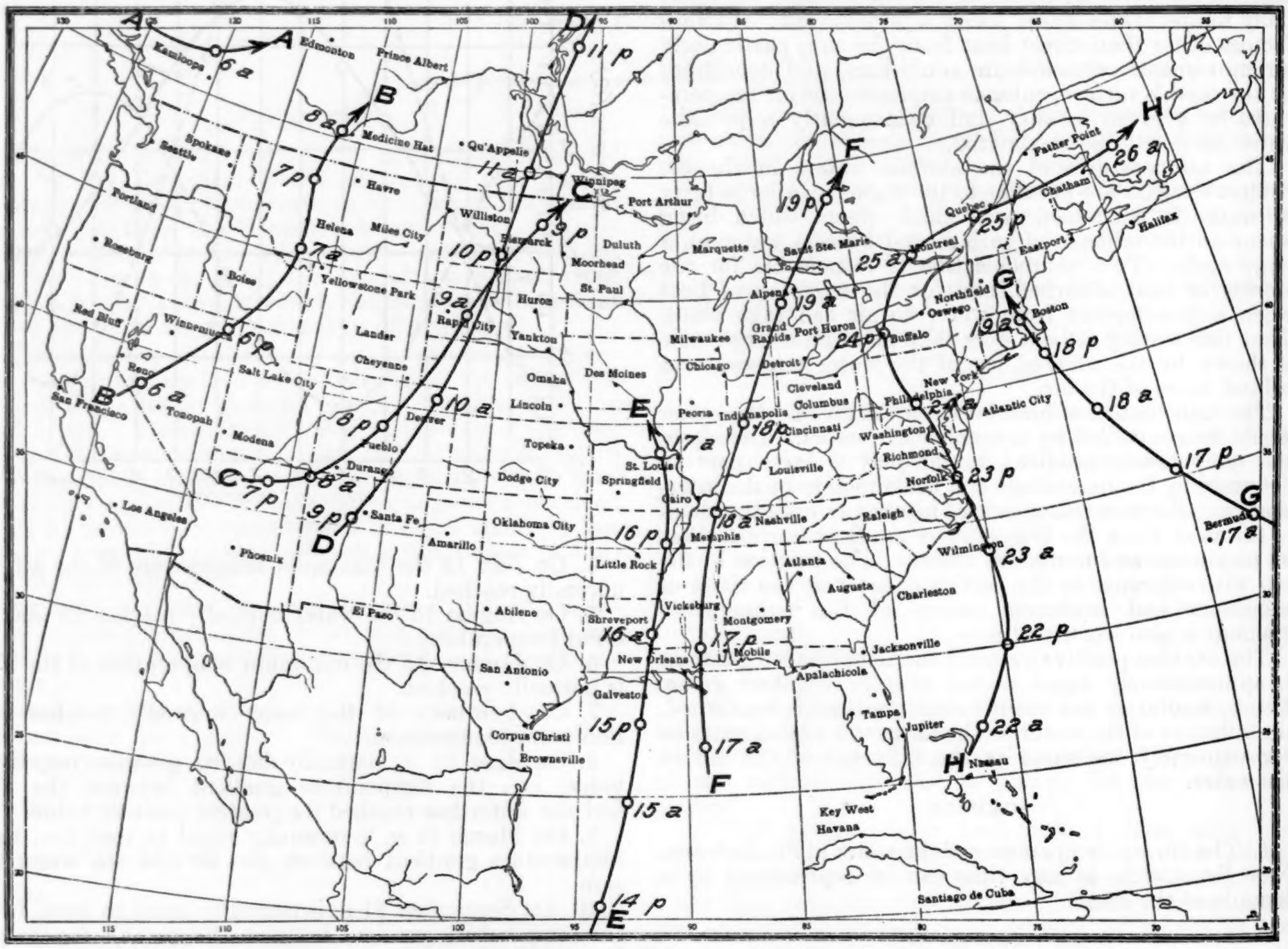
Month	Observed values			Calculated values, y_3
	y_1	y_2	$y_3=y_1-y_2$	
January	1.0	−6.4	7.4	7.2
February	.0	5.4	5.4	4.7
March	.9	1.1	−.2	1.0
April	3.1	5.9	−2.8	−2.9
May	6.5	11.2	−4.7	−6.0
June	8.9	15.1	−6.2	−7.4
July	11.6	18.4	−6.8	−6.8
August	12.4	17.3	−4.9	−4.3
September	12.1	13.9	−1.8	−.6
October	10.2	8.5	1.7	3.3
November	7.1	3.1	4.0	6.6
December	3.5	−3.4	6.9	7.8

A REMARKABLE OCCURRENCE OF CYCLONES IN SERIES

By EDWARD H. BOWIE

[Weather Bureau, San Francisco, Calif., September 1933]

The occurrence of cyclones in series is a phenomenon with which all those having to do with the preparation of synoptic charts are more or less familiar. In the Bjerknes frontal theory such a series is designated a *cyclone family.*



Tracks of cyclones in the United States during October 1923.

In an article on "The Planetary System of Convection", by William R. Blair, in the MONTHLY WEATHER REVIEW, April 1916, vol. 44, p. 194, one finds the following:

Some years ago Mr. E. H. Bowie called the writer's attention to the fact that the low-pressure areas enter and cross the United States in series. The first low-pressure area in such a series will enter the country well to the north and pursue a course eastward over the northern States; the second enters somewhat farther south, and so on. The last low-pressure area of the series may enter the extreme southwest, and pass along the Gulf and Atlantic coasts, although the series do not always carry as far south as this. The series follow each other in close succession. The relation between

these series of low-pressure areas and the general meridional movement of the atmosphere seems to be quite direct. The fact that the low-pressure areas of any series pursue more nearly the same path across the Atlantic than they have pursued across the continent seems to indicate that the change in position of the thermal equator occurs mostly over land areas. It is possible that the meridional motion found over the continental area is compensated by a meridional motion in the opposite direction of [*over*] the oceans.

It is a fact that the cyclones of the North American Continent often occur in series. The first storm of each series runs its course far to the north, and each succeeding one farther and farther south and east usually until the entire continent is passed, after which any subsequent member of the series forms over the Atlantic Ocean.

It should not be understood that the places of first appearance of the cyclones in successive groups are the same, but only that there is a tendency for the subsequent disturbances of a series to run farther to the south and east following the occurrence of the first, a fact that may be verified times almost without number by referring to the charts in the MONTHLY WEATHER REVIEW that show the chronological records of the tracks of cyclones.

Of all the charts of this kind examined, that of October 1923 best illustrates the tendency of cyclones of the North American Continent to occur in series. This chart of October 1923 is here reproduced in somewhat modified form to bring out the cyclone series of that month in a more detailed way. The first of the cyclone tracks of the series shown is designated *A*, and it lies over British Columbia. Its life on the continent was short, as it was charted for only one observation, that of the morning of the 6th. The second track, designated *B*, starts over Nevada and ends over southern Alberta. The third, *C*, begins over Arizona and ends over northeastern North Dakota. The fourth, labeled *D*, begins over New Mexico, and being long-lived, ends in the region of Hudson Bay. The *E* track begins over the southwest part of the Gulf of Mexico and ends over Missouri, and the *F* following the *E* also begins over the Gulf of Mexico and ends over Ontario; *G* begins in the vicinity of Bermuda and ends near Cape Cod, while the *H* track begins to the southward of Cuba, crosses the coast line near Cape Hatteras, and ends near the mouth of the St. Lawrence River. The *H* track completes the series as far as the North American Continent is concerned. Possibly its continuance on the North Atlantic Ocean could be followed, but the material with which to do this is not available to the author.

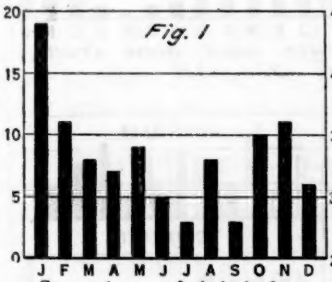
An inspection of the chart of cyclone tracks in the MONTHLY WEATHER REVIEW for October 1923 shows that at the time cyclone *F* was forming and passing northward from the Gulf of Mexico, the first cyclone of a new series had appeared in Saskatchewan, followed by the formation of a second of the new series over Nevada and later a third of the series over the upper Rio Grande Valley. Thus it would appear that all of the cyclones of October 1923, between the 6th and the 31st, belonged to two series, the first of which began with *A* on the 6th in British Columbia and ended with *H* on the 26th in the St. Lawrence Valley. The equal of this interesting series is not to be found in the MONTHLY WEATHER REVIEW charts of cyclone tracks for months previous to and following October 1923, although many interesting series are preserved in these charted records.

FOG FORMATION AND DISSIPATION IN THE OKLAHOMA CITY AREA, 1920 TO 1931, INCLUSIVE

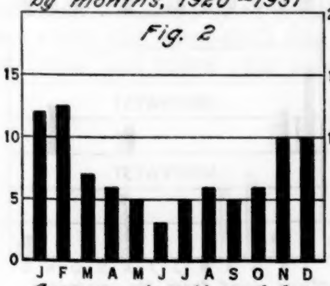
By PERRY O. EPPERLY

[Weather Bureau, Oklahoma City, Okla., October 1933]

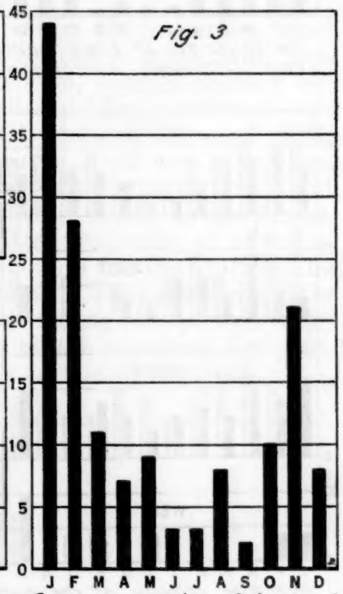
Fog is most frequent in the Oklahoma City area in January and most lasting in February. An average of 44 hours of fog may be expected in January with an



Percentage of total fogs by months, 1920–1931



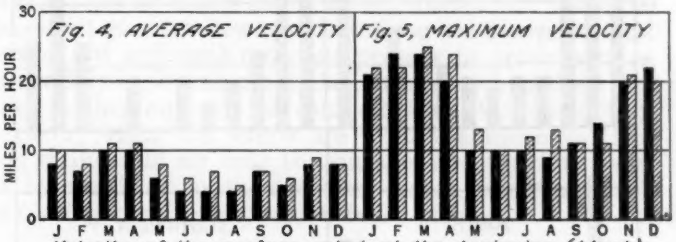
Average duration of fogs in hours, 1920–1931



Average number of hours of fog by months, 1920–1931

average duration of 12 hours. In unusual cases fog has continued with very little variation in intensity for 64 hours. Usually, however, it does not last more than 12 hours. The average number of fogs per day and the average duration of each fog gradually decrease as summer approaches. The minimum average duration is in July and is not more than 3 hours.

The duration, frequency, and intensity of fog are largely regulated by pressure, temperature, and humidity, though wind direction, sky conditions, and convection

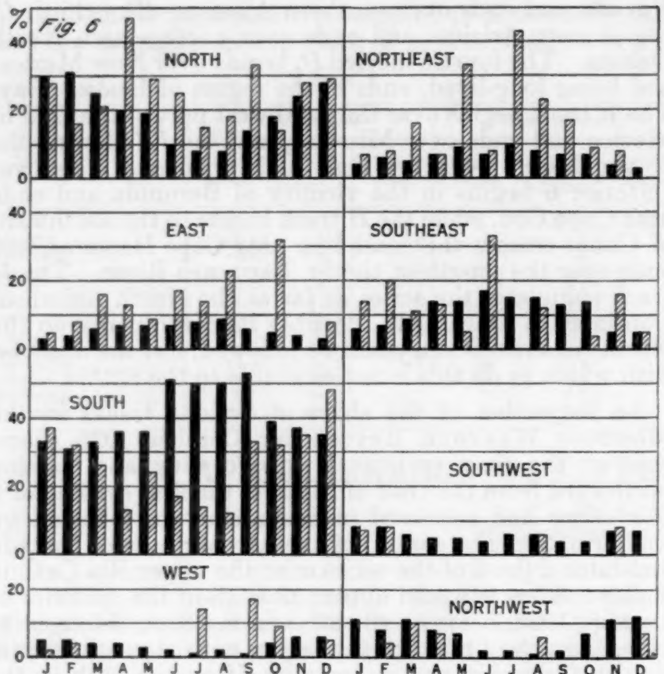


Velocity of the surface wind at the beginning (black) and the ending (shaded) of fog, 1920–1931

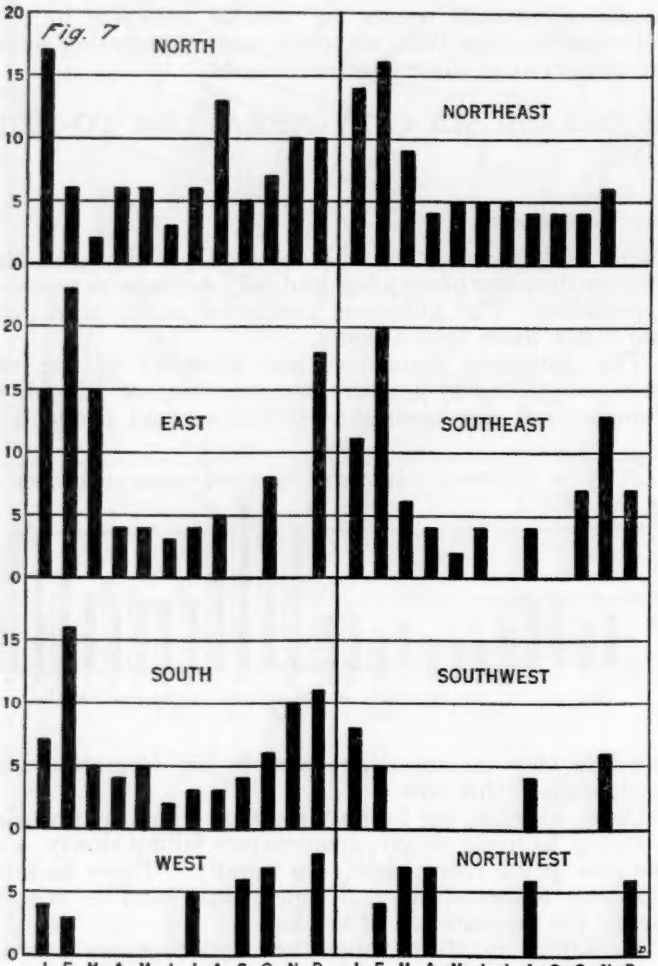
currents play an important part in fog formation and dissipation in this area.

On an average, fog formation occurs when the pressure is steady to rising slowly, temperature falling slowly, and the dew point rising slowly to rapidly. These factors, pressure, temperature, and dew point, tend to remain steady for the duration of the fog.

Variations in the temperature and pressure act directly on the humidity, and cause changes in the density of the fog. A shift of the wind from either south or north to easterly usually intensifies the fog and increases its duration, while a shift to westerly in almost all cases

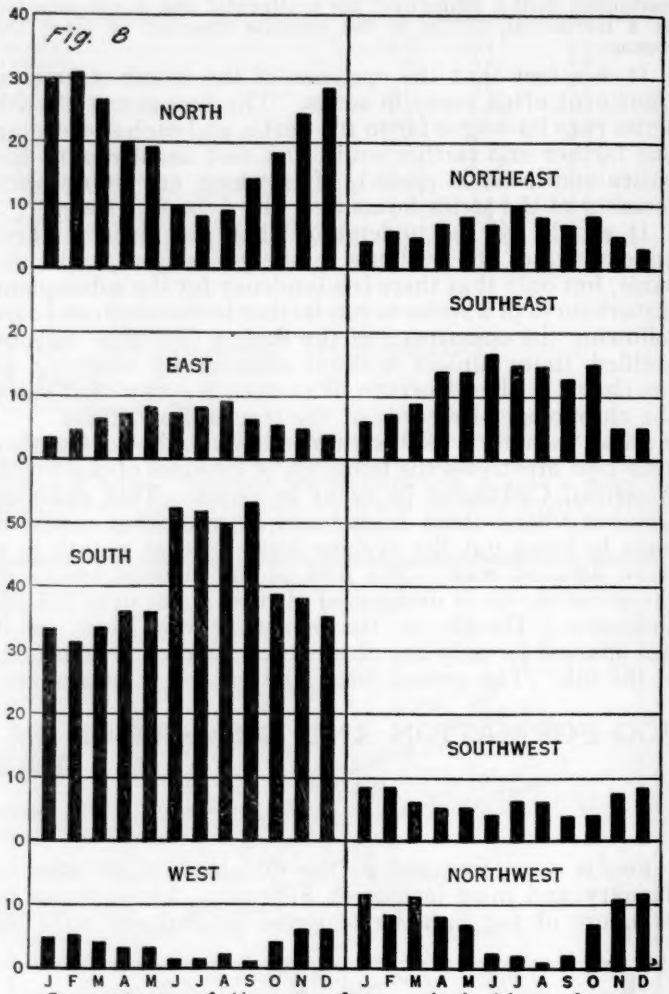


Probability of fog (shaded) and wind (black) occurrence from the different directions

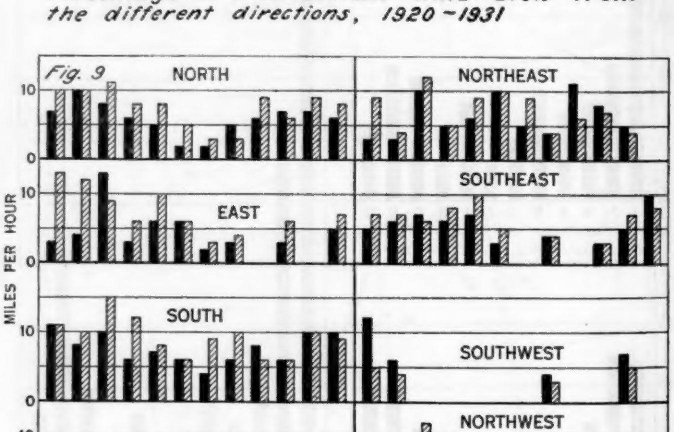


Average duration of fog, in hours, formed on winds from the different directions, 1920–1931

brings about its dissipation. An intermediate layer of clouds commonly prolongs the fog, while under a clear sky it will usually dissipate much quicker, especially after sunrise. Convection currents cause the fog to lift, and if the convection is sufficient to cause light to moder-



Percentage of time surface wind blew from the different directions, 1920–1931



Average velocity of the surface wind from the different directions at the beginning (black) and the ending (shaded) of fog, 1920–1931

ate precipitation, the fog, in most cases, is dissipated by the end of the rain.

All the fog recorded for this area, with very few exceptions, begins between 2 and 7 in the morning. When the sky is overcast and the humidity is high for several hours, or when the area is subjected to several days of moderate rains, fog may be expected to form during the afternoon and evenings.

During the summer most of the fog is of the radiation type. This type, though also occurring tn the winter is most frequent during the spring and in the fall. During clear cool nights when the pressure is steady and the wind light in any direction from south through east to north, fogs are likely to form. If there has been a rainy period of several days they are extremely likely to occur. These fogs generally dissipate soon after sunrise. If there is a cloud covering, dissipation is much slower and the fog may last several hours after sunrise. If the temperature conditions are unfavorable for dissipation, the fog will continue until a decrease in pressure forces it to lift, after which it often remains as low stratus or strato-cumulus clouds.

The surface wind here is westerly a very small percentage of the time and there are but few fogs recorded as then forming. In practically all cases a shift of the wind during fog to a westerly direction has brought about dissipation. It is believed that this dissipation is largely due to warm dry air from the semiarid prairie country to the soughwest, west, and northwest. During the late fall, winter, and early spring, fog may be expected to dissipate before 1 o'clock in the afternoon, while during late spring, summer, and early fall, dissipation will usually occur before 9 in the morning. Under most conditions fogs dissipate with rapid rises in temperature and pressure, however, convection currents cause it to lift and warm dry westerly winds reduce the humidity to such an extent that the fog dissipates.

RAIN-BEARING WINDS OF CENTRAL OKLAHOMA

By PERRY O. EPPERLY

[Weather Bureau, Oklahoma City, Okla., October 1933]

A study of the relation of the rain-bearing winds of central Oklahoma to the prevailing direction of the wind for this area indicates that the wind of rain periods has little relation to the prevailing direction of the surface wind.

During the entire year except February, the prevailing direction of the surface wind is south, however, during late fall, winter, and early spring the wind is north much of the time. In January the percentage of north winds is only slightly below that of winds from the south, while during February they are equal. Through spring and summer the wind is increasingly from the south and reaches a maximum in September. The percentage of westerly winds is slightly larger during the late fall, winter, and early spring than during the summer. During the late spring, summer, and early fall easterly winds, especially northeast and southeast have their greatest percentage.

Although the prevailing direction of the surface wind is south the wind during rain periods is north from September through January to March, equally divided between north and south in April and May, northeast during June and July, and equally divided between north and southeast in August. During April and May rains the wind almost always shifts from south to north and during June and July rains from south to northeast. This is the period of the greatest frequency of thunderstorm development, which accounts for the shift of the wind to the northerly directions. Through the winter months this change of direction during rain periods takes place along the wind-shift line of the numerous low-pressure areas that move over this section of the State.

Thunderstorm development in the winter months is slight; however, an occasional storm is reported in connection with a violent wind shift. From December to February the percentage of rains with thunderstorms is small. From February to May it reaches 68, and in June 80. It then decreases to 71 in September, 51 in October, and 24 in November. The prevailing direction of the upper air for this section is from southwest to northwest during the entire year. Consequently the majority of the thunderstorms occurring at this station move in from these directions.

The prevailing south winds of this area come largely from the subtropical high-pressure area to the south and from anticyclonic systems when they are centered over the southeastern portion of the United States. When these winds blow over the Gulf of Mexico they bring in warm damp air to this section both at the surface and aloft. When this warm damp air associated with the eastern half of a disturbance is underrun by cool air from the northwest and north, showers and thunderstorms occur. When, instead of southerly winds from the Gulf, the air comes as southwest winds from the semiarid desert country, low clouds and fog are dissipated and there is not sufficient moisture present to produce more than widely-scattered precipitation, even when there are underrunning currents of cold air from the northwest. However, when the winds are from the northeast and east, giving cold air near the surface, and they are overrun by south or south-southwest warm, moist air from the Gulf, general precipitation takes place.

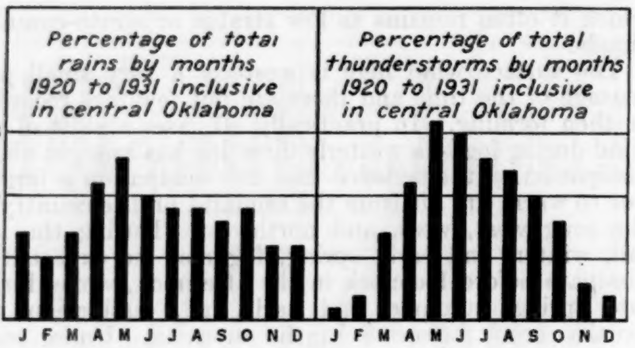
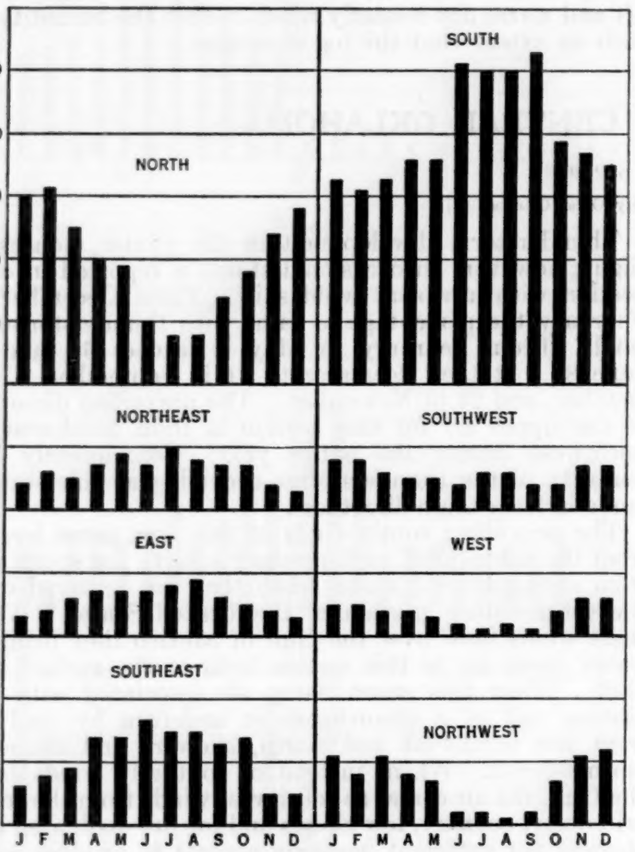
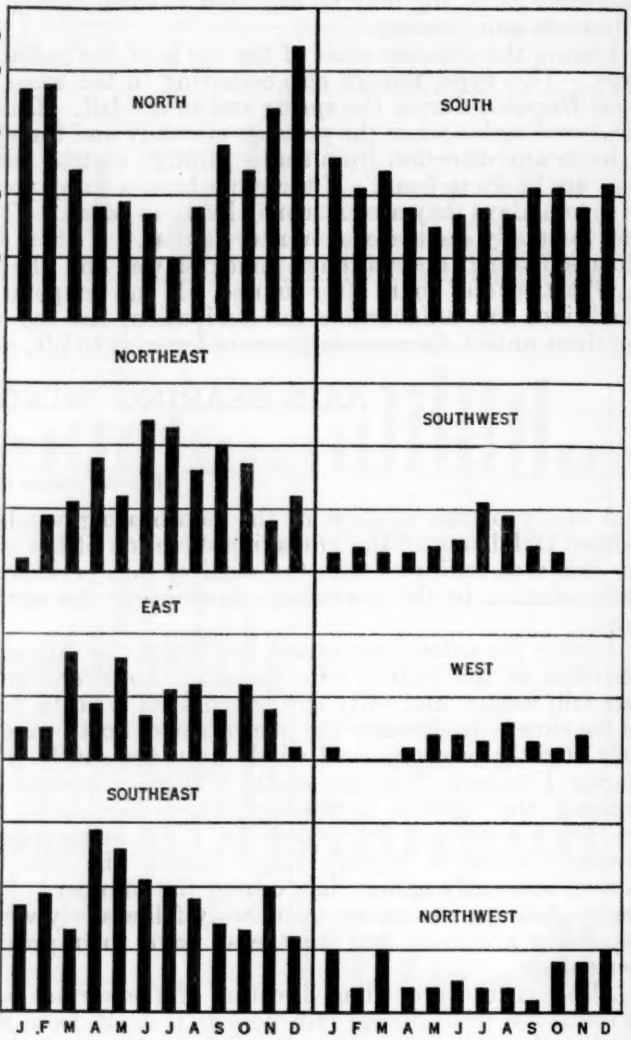


FIGURE 1.



Percentage of time the wind blew from the different directions, 1920 to 1931 inclusive in central Oklahoma

FIGURE 2.



The prevailing direction of the wind during rain, 1920 to 1931 inclusive in central Okla.

FIGURE 3.

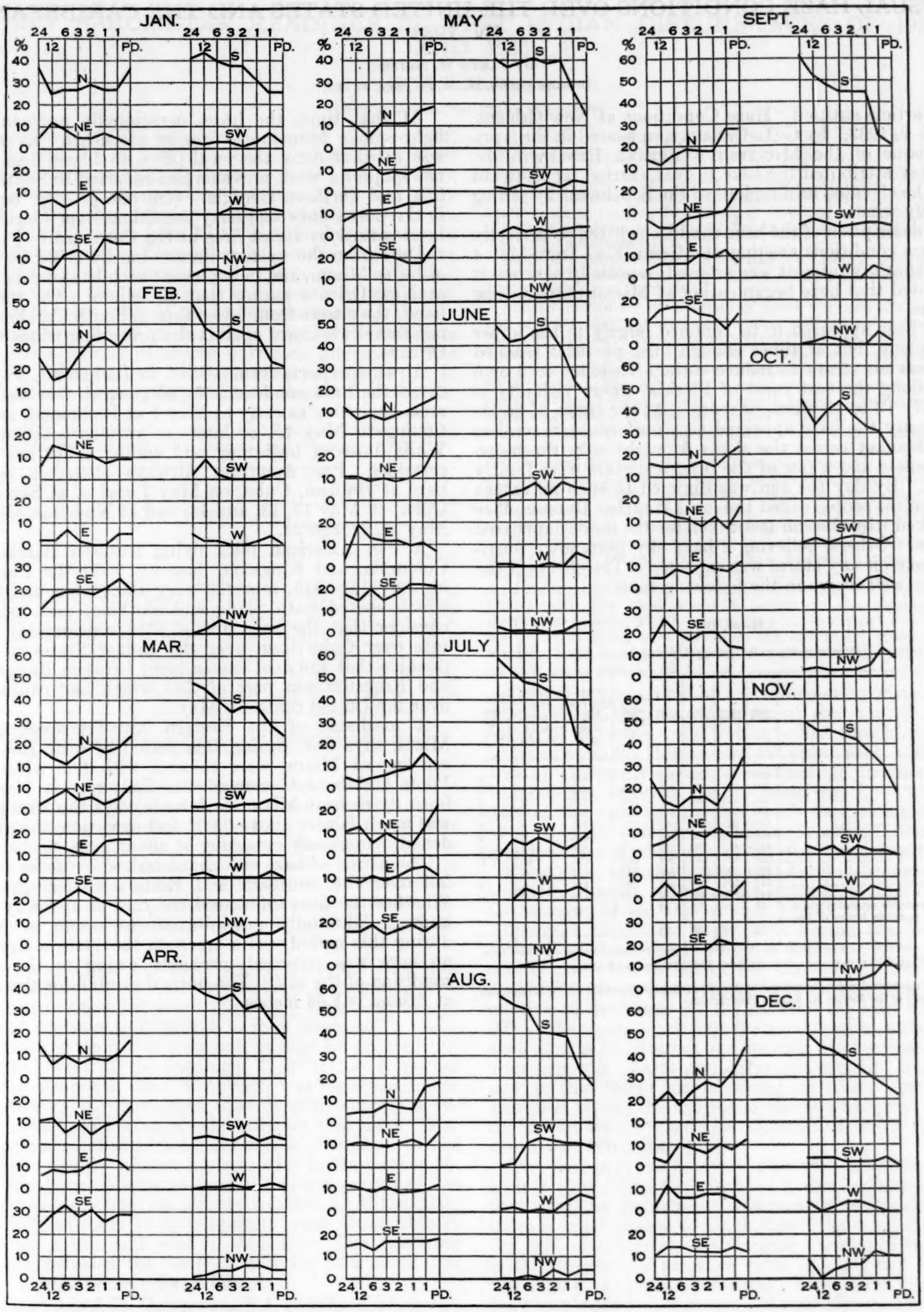


FIGURE 4.—Percentage of time that wind blew from the different directions 24, 12, 6, 3, 2, and 1 hour preceding, the hour of beginning, and during the rain, for each of the 12 months, 1920-31, inclusive, in central Oklahoma.

UNUSUAL HAZE CONDITIONS OVER THE UNITED STATES AND THE CARIBBEAN SEA IN 1933

By JAMES W. SMITH

[Weather Bureau, Miami, Fla., Sept. 26, 1933]

An article entitled "Haze Conditions at New Orleans, May 5–9, 1933," by G. L. Canaday, appeared in the April 1933 issue of the MONTHLY WEATHER REVIEW. Mr. Canaday attributed the haze to dust, carried far eastward from the elevated arid regions of the Southwest by strong westerly winds.

His description of the haze conditions fitted so perfectly the haze conditions existing at Miami, Fla., from May 4 to 13, that my interest was aroused; especially so when it was noted that haze began earlier at Miami than at New Orleans.

The haze appeared to be confined largely to the upper atmosphere, but at times enough dust particles reached the lower air strata to reduce surface visibility to 5 or 6 miles along the east coast of Florida, where visibility is normally 12 to 15 miles, or more. At the times of greatest density the haze appeared as a uniform structureless white blanket across the sky. At night only the moon and planets and a few of the brightest stars were faintly visible. By day the sun was dimmed to such an extent that several people called the local Weather Bureau office and asked why the sun (mistaken for the moon) appeared so large. Others, believing a hazy sky portends a hurricane, asked if any storm was expected. The effects of the haze are well shown in the following table:

Miami, Fla.

[Sun-intensity units (gram cal. per sq. cm.)]

	1930	1931	1932	1933	Average, 1930–33	Average, possible or clear sky	1933 average daily clouds	Precipitation
May 4	445	330	387	337	375	475	[1] 9	0
May 5	452	389	427	368	409	475	[1] 8	0
May 6	446	353	352	378	382	475	2	0
May 7	400	365	439	393	399	475	1	0
May 8	464	205	467	365	375	475	2	0
May 9	462	470	356	367	414	475	0	0
May 10	453	472	382	333	410	475	[1] 9	0
May 11	329	468	386	291	368	475	[1] 10	T
May 12	439	395	373	340	387	475	6	0
May 13	472	464	266	387	397	475	4	0
May 14	446	476	399	350	418	475	[1] 8	0
Percent of possible intensity units	85	86	75	74				
Percent of possible hours of sunshine	61	73	56	71				

[1] Mostly high thin clouds—or a few cirroform clouds mixed with haze.

NOTE.—Sun-intensity data furnished by Dr. O. J. Sieplein, director of the Miami Sun Ray Research of the Joseph H. Adams Foundation.

At that time, the haze, occasionally augmented by light smoke from muck fires in the nearby Everglades, was attributed by the local office to forest fires, which newspapers a week previous had reported in South Carolina and northern Georgia. (On one or more occasions in the past smoke and hazy conditions over Florida have been caused by forest fires in the Carolinas.)

Dust from the western deserts hardly could be carried as far as Miami, and in any event such haze would appear at New Orleans earlier than at Miami. On the other hand, the smoke from forest fires in South Carolina could not travel westward against the prevailing winds to New Orleans.

Airways reports from Miami to Richmond, Va., indicated the haze conditions to be general over the entire area, beginning as early as May 1 at Richmond, and continuing to May 15, or later, at various coast stations. While dates of beginning and ending could not be ascertained, Pan American Airways observers reported haze at Habana, Cuba, on May 7 and 8, at San Julian, Cuba, on May 12, 13, and 14, and at Nuevitas, Cuba, on May 19, 22, and 24.

A Pan American pilot flying between Barranquilla, Colombia, and Kingston, Jamaica, over the Caribbean on July 14, 1933, reported very thick volcanic [?] dust which coated both plane and clothing, and, when we consider that the haze drifted at a considerably slower rate over Cuba than over the United States, it seems possible that the dust encountered between Barranquilla and Kingston was part of that which had caused haze over the United States in May.

A mechanic of the Eastern Air Transport line at Miami says that during this period of haze the planes arriving at Miami were covered with fine white dust. Pilot Archibald Comer of the Eastern Air Transport lines, flying from Miami to Atlanta, says the haze usually was much fainter above 2,000 feet elevation, the greatest density commonly occurring at about 1,000 feet altitude.

The period of haze was characterized by deficient rainfall over the Southern and Eastern States, generally. Whether the dust influenced the rain in any way is unknown. The only precipitation to occur at Miami, during this period was a trace on the 11th, a day when no haze was recorded, probably owing to the cloudy condition of the sky. The normal rainfall for this period at Miami is 1.56 inches.

LOW BAROMETER READINGS IN WEST INDIAN DISTURBANCES OF 1932 AND 1933

By W. F. McDONALD

[Weather Bureau, Washington, October 1933]

The summer of 1933 was, even at the end of September, characterized by a record-breaking number of West Indian disturbances, and these storms produced five ships' barometer observations between 27.40 and 27.99 inches. Five other pressure readings on ships at sea were reported in the range from 28 to 28.50 inches, making 10 cases this year (up to September 30), in which ships have experienced and verified in mail reports to the Weather Bureau, such uncommonly low barometric minima in their encounters with West Indian hurricanes.

Pressures of 28.50 or lower in tropical disturbances characterize storms of severe hurricane intensity. The following table records all such observations so far in hand for the 3 months, July to September, inclusive, 1933.

Table of ships' barometer observations, 28.50 inches or lower, in West Indian hurricanes of July, August, and September 1933

Date	Name of vessel	Position: Latitude N.		Position: Longitude W.		Lowest barometer
		°	'	°	'	
July 5, 1933	Am. S.S. Lena Luckenbach	25	32	90	40	28.50
Aug. 18, 1933	Nor. S.S. Tana	[1] 23	00	[1] 54	30	[2] 27.98
Aug. 30, 1933	Br. S.S. Jamaica Pioneer	22	10	72	30	27.47
Sept. 2, 1933	Am. S.S. Harvester	[1] 25	00	[1] 86	00	27.99
Sept. 11, 1933	Fr. S.S. Washington [3]	23	15	61	40	27.96
Sept. 15, 1933	Am. S.S. El Oceano [3]	[1] 34	00	[1] 74	30	28.24
Sept. 16, 1933	Am. S.S. Shenandoah [3]	36	35	75	00	28.43
Do	Am. S.S. Gulf of Mexico [3]	36	35	74	41	28.48
Sept. 17, 1933	Ger. S.S. Bremen [2]	39	54	69	16	28.50
Sept. 20, 1933	Am. S.S. Virginia	[1] 18	30	[1] 83	05	27.40

[1] Positions closely estimated.
[2] Uncorrected aneroid reading, but evidence indicates instrument in good order.
[3] Observations of Sept. 11–17, all obtained in same storm.

The 5 readings below 28 inches were obtained in 4 separate storms. Furthermore, the lowest reading in each of these storms was observed within 1 or 2 days after the time at which the disturbance became definitely located in our reports, and no lower readings thereafter have as yet come to light, although in all cases these storms appear to have increased in extent and destructive power as they passed onward to later stages of development.

This group of records therefore supports the view that tropical disturbances often, or perhaps commonly, arise as intense vortices of small diameter, which expand in area and decrease in intensity as they progress.

As bearing upon this question, it may be pointed out that the lowest of the readings, 27.40 inches (reported from the American liner *Virginia*), was observed under the following circumstances that clearly indicate a recently developed vortex of extraordinary sharpness. Meteorological conditions were somewhat disturbed in the Caribbean Sea for almost a week prior to September 20, when the *Virginia* encountered the storm described below, but no ship reported stormy weather until the 19th, when definite signs of development were observable in the region south and west of Jamaica. The following afternoon revealed the focus of activity as a small but intense hurricane near Swan Island.

The report of J. E. Handran and J. F. Wilson, observers on the *Virginia* (Capt. C. V. Richardson), is worthy of quotation at length and extracts are given below. The aneroid barometer used on the ship is subject to a correction of —0.05 inch, which was applied to the readings before quotation in this report, which says:

At 5 p.m. (Sept. 20) it was blowing a moderate (NNE.) gale. At 6 p.m. the wind had further backed into the NE., force 8, with the barometer reading 29.95 inches. A speed of 17.5 knots was at this time cut down to 14 knots due to the heavy head swell which was being encountered.

At 6:55 p.m. the wind and sea had increased to such an extent that a further reduction in speed was necessary, to about 8 knots. Position 18°38' N., 83°07' W.

Shortly before 8 p.m. a squall of great violence struck the ship and at 8 the ship was hove to, heading 180°, bringing the wind on the port quarter. Revolutions were adjusted to keep bare steerageway. The aneroid barometer at this time, approximately 8 p.m., was reading 28.74 inches. Five minutes later it was down to 28.50 inches. The wind was now blowing in almost continuous squalls of great violence, with torrential rain. The noise from the wind was terrific, it being impossible to hear.

At 8:20 p.m. the wind suddenly ceased and looking directly overhead a few stars were visible over a small area. Men's ear drums were ringing, with the barometer standing at 27.40 inches during the calm center or "eye" of the hurricane. While in the calm area in a high confused sea the vessel was headed 55° true in anticipation of a change of wind. At 8:35 p.m. the wind struck in from the SSW. with slightly less force than before.

The wind continued to blow in squalls of hurricane violence from the SSW., with a rapidly rising barometer, when at 9 p.m. the glass stood at 28.60. Between 9 and 10 p.m. the wind moderated sufficiently to allow of bringing the vessel back to the course (150°) with the wind about 4 points on the starboard bow. Barometer reading 29.20. From 10 p.m. the speed was increased to full at 11 p.m., at which time the barometer stood at 29.40; wind S., force 9. At midnight the wind had further decreased to force 8; barometer, 29.66.

Careful examination of the information given in this report shows that the diameter of the ring of pressure below 29.50 inches could not have been much more than 50 miles when the ship crossed the storm area. The inner area of extreme violence, encompassing pressures below 28.50 inches, passed while the vessel was hove to. That part of the vortex, therefore, may be estimated as not over 10 to 12 miles in diameter, because 1 hour's progression carried that section of the hurricane past the drifting ship, and the evidence at hand indicates that the storm movement between the evening of the 20th and the morning of the 21st was not rapid.

Increase in the hurricane area during the few hours covered by these observations is indicated by the slower rate of rise than of fall in the barometer. This hardly could be attributed to a variation in the ship's movements relative to the storm for the route of the ship was about 90° to the storm track and the variations in sailing speed were similar in entering and leaving the hurricane. The later synoptic charts also carry the story of increase in size as this storm moved along its track westward to Tampico, where the hurricane struck with great violence on September 24 when the diameter of the 29.50 isobar was about 300 miles.

The fact that the center of this very small vortex had a clear spot "directly overhead", also indicates that at that time the disturbance was moving rather slowly, for there is much reason to think that with rapid movement the core of a tropical disturbance commonly is inclined in the direction of advance, with no clear sky visible in the region of lowest pressure. This point is not yet fully established; it is worthy of special notice and ships' observers are requested to supply more information on the character of the sky at the center of such disturbances when encountered.

The pressure (27.47 inches) observed on the British steamer *Jamaica Pioneer,* August 30, near Turks Island, ranks next lowest among the cases here reviewed. Examination of the detailed report in this instance also shows a very sharp vortex. The ship was only 7½ hours within the circle of pressures below 29.50 inches, and about an hour and 10 minutes while it was below 28.50 inches. The storm could not have been more than 2 days old at the time the *Jamaica Pioneer* crossed the center. This hurricane was moving quite rapidly at the time, and no clear eye was reported. Three days later the American steamer *Harvester* recorded 27.99 inches in this storm.

Readings below 28 inches in the other two storms, as reported by the Norwegian steamship *Tana* (Aug. 18), and the French ship *Washington* (Sept. 11), were also obtained at times when we must assume the cyclones to have been at a comparatively early stage of development. In neither of these storms can any center be definitely located or actual storm winds found in our reports more than 1 or 2 days prior to the date of the ship's encounter with the vortex.

The table carries five records taken at different times in the same storm, between September 11 and 17. It is of interest to note that these readings together constitute a consistent progression of dates, positions, and pressure values; this must be because the central pressure slowly increased as the storm progressed along its track.

In this connection, and bearing upon the question of the pressure distribution in tropical disturbances, reference is made to a report (not previously published in the REVIEW) obtained from the British steamer *Phemius,* which was involved for 4 days in intense hurricane conditions in the western Caribbean Sea in early November 1932. The meteorological log of this ship's experience, as given in detail in the British MARINE OBSERVER for October 1933 (vol. 8, pp. 123–125), indicates a hurricane of full maturity and of what appears to be unusual complexity of structure.

The lowest pressure observed on the *Phemius,* 27.01 inches (914.6 mb.), was reached on the 5th near 14° N. 79° W., and within a few hours after the vessel entered the hurricane area. This is one of the lowest barometer readings ever observed at sea level, and the lowest fully authenticated reading in the West Indian region so far as can be ascertained at this writing.

The fall in barometer as this vortex approached was very rapid, and was attended by hurricane winds so intense that superstructures on shipboard were badly damaged, and the ship's funnel actually torn out and blown overboard. The vessel was from that time disabled, and wallowed in the seas throughout the remainder of the storm.

The barometer did not rise with equal promptitude, however, and the height that prevailed a few hours before the vessel's encounter with this terrific vortex was not again reached for 4 days. Instead, there was a partial rise, followed by several marked decreases, to 28 inches on the third day and 27.92 on the fourth, as if there might have been either a family of subvortices or vacillation in the movement of the primary storm center. During those 4 days the ship was involved in continuous storm conditions of great severity, with the barometer for 3 days never rising above 28.50 inches.

This hurricane was the same that on November 9, 1932, advanced northward across Cuba and devastated the city of Santa Cruz del Sur, with the loss of several thousand lives. Its meteorological history in the western Caribbean has not been fully worked out, but the record of the *Phemius* very clearly shows an extent and complexity of structure that throws this case into great contrast with the simpler vortices reported in the ship's observations of 1933.

TROPICAL DISTURBANCES OF SEPTEMBER 1933

By C. L. MITCHELL

[Weather Bureau, Washington, October 1933]

Tropical disturbance of August 31–September 7.—This disturbance was central about 150 miles north of Puerto Rico the morning of the 1st. It evidently was attended by winds of hurricane force nearer its center at this time, inasmuch as the S.S. *Gulf Wing* reported a barometer reading of 28.98 inches and a wind velocity of 80 miles per hour about 150 miles east of Turks Island the evening of the 1st. The center passed some distance north of Turks Island during the night of the 1st-2d and over Harbour Island, about 2 miles northwest of the island of Eleuthera, Bahamas, the morning of the 3d. There was a calm of 30 minutes at this place. Previously the wind had reached an estimated velocity of 140 miles per hour. At 4 p.m. of the 3d, northwest storm warnings were ordered displayed at Miami, hurricane warnings north of Miami to Melbourne, Fla., and northeast storm warnings north of Melbourne to Jacksonville. At 10 p.m. storm warnings were displayed on the west Florida coast north of Key West to Cedar Keys.

The storm center apparently passed directly over Jupiter Inlet, Fla., where there was a lull of 40 minutes beginning near midnight of the 3d. The lowest barometer reading at Jupiter was 27.98 inches and the estimated maximum wind velocity 125 miles per hour. At West Palm Beach the lowest barometer reading was 28.77 inches with a maximum wind velocity close to 80 miles per hour. According to the official in charge at Miami, the only evidence of damage at West Palm Beach was the effects of high winds upon trees and shrubbery. However, a number of plate glass windows were broken and the damage in this respect would have been much greater except for the extensive protective measures taken. Between West Palm Beach and Jupiter, and extending northward to Fort Pierce, there was serious damage to electrical transmission lines and to telephone and telegraph wires, with many poles broken off or blown over. At Stuart there was serious damage from both wind and water. The most extensive damage in the entire storm area was at Olympia Beach, north of Jupiter Inlet, where there was widespread destruction of trees and shrubbery and serious damage to houses. The greatest loss was to the citrus crop in the Indian River section from Jupiter to Fort Pierce. In the vicinity of Stuart there are several groves that sustained a 100 percent loss of fruit and the uprooting of many trees. The estimated loss of citrus fruit for the State is 16 percent, or 4,000,000 boxes.

This storm recurved to the north during the afternoon of the 4th when its center was near the coast north of Tampa. Moving very slowly northward with diminishing intensity during the next 2 days it dissipated over Georgia on the 7th.

Tropical disturbance of September 10–21.—Although conditions were disturbed over and east of the Leeward Islands from the 7th to the 9th, it was not until the 10th

that a definite center could be located. This center was then about 300 miles northeast of the Island of St. Martin. By the morning of the 11th it was evident that the disturbance was one of considerable intensity, and it was so stated in the advisory issued at 10 a.m. of that date. This disturbance continued to move northwestward with gradually increasing intensity until the 15th, when it recurved and moved almost directly northward. Its center passed slightly west of Cape Hatteras about 8 a.m. of the 16th, after which it moved north-northeastward for about 12 hours, and then northeastward, reaching Nova Scotia the morning of the 18th, and extreme southern Iceland on the 21st.

Storm warnings were ordered at 4 p.m. of the 14th from Jacksonville, Fla., to Beaufort, N.C. At that time the disturbance had not begun to recurve and it was apparently headed for the northern South Carolina, or southern North Carolina, coast. At 10 p.m., storm warnings were extended northward along the coast to the Virginia Capes. The following morning the storm center was about 350 miles east of Savannah, Ga., and the indications were that it would reach the North Carolina coast not far from Cape Lookout in about 12 hours. Accordingly, hurricane warnings were ordered displayed at 10:30 a.m., from Wilmington to Cape Hatteras, and northeast storm warnings north of the Virginia Capes to Boston.

At 4 p.m. whole-gale warnings were displayed north of Hatteras to the Virginia Capes. At 8 p.m., the center was about 100 miles south of Cape Hatteras, moving almost directly northward, and the hurricane warnings at Wilmington were changed to northwest storm warnings at 9:30 p.m. At 10:30 a.m. of the 16th whole-gale warnings were ordered along the coast (but not at Baltimore and Philadelphia) north of the Virginia Capes to Atlantic City, and hurricane warnings were changed to storm warnings north of Wilmington to Hatteras. The 2 p.m. special reports indicated that the storm was beginning to recurve toward the northeast and that the center would pass some distance east of Cape Henry and the whole-gale warnings north of Hatteras to the Virginia Capes were changed to northwest storm warnings at 4 p.m. At 8 p.m. the storm was central about 125 miles south of Atlantic City, apparently moving northeastward. At 9:30 p.m., northeast storm warnings were extended north of Boston to Eastport, Maine, and whole-gale warnings on the coast north of the Virginia Capes to Atlantic City were changed to northwest storm warnings. The following morning when the storm center was about 150 miles east of Atlantic City, whole-gale warnings were ordered displayed from Provincetown to Nantucket, Mass.

The principal damage done by this storm was from a short distance south of New Bern, N.C., to the Virginia Capes. The following is quoted from a report by the official in charge, Wilmington, N.C., relative to a trip of inspection of the storm area:

* * * Very little damage was noted until a point a few miles southwest of New Bern was reached. Great damage was done by wind and high water in New Bern and vicinity; many telephone- and power-line poles blown down, numerous large trees uprooted or broken off, and houses and other buildings injured by falling trees and in some cases unroofed. At least one tree 4 feet in diameter in the heart of the city was uprooted. Water reached a height of 3 to 4 feet in some of the streets which is about 2 feet higher than the previous record which occurred in September 1913. Along the highway from New Bern toward Beaufort at least 100 trees 10 inches or more in diameter were blown down. In Morehead City and Beaufort damage was apparently slightly less than in New Bern, but old residents in Beaufort declare the storm was the worst they had ever experienced. It is estimated that the maximum velocity of the wind in the New Bern-Beaufort area was at least 125 miles per hour. Loss of life was due chiefly to high water in isolated localities north of Beaufort from which escape was difficult or impossible. According to the latest reports a total of 21 lives were lost. Property damage along the entire North Carolina coast will total, according to early estimates, more than $1,000,000.

At Cape Hatteras the lowest barometer reading was approximately 28.25 inches about 7 a.m. of the 16th. The highest wind velocity preceding the arrival of the center was 68 miles per hour from the east and the highest after the center passed, 76 miles per hour from the northwest (estimated because 1 cup of the anemometer was blown away).

The damage done by the storm at Norfolk and the other places in the Virginia Capes section was comparatively slight and was far less than that caused by the August 1933 storm. Much credit is given by the business interests and newspapers of Norfolk to the Weather Bureau for its timely and accurate warnings. There was ample time for complete preparation for the storm, thus holding losses to a minimum. The highest wind velocity in the Capes section was 68 miles per hour from the northeast at Cape Henry. Farther north along the Atlantic coast the highest velocities were 48 miles per hour at Atlantic City and 52 miles per hour at Block Island, R.I., and Nantucket, Mass. No great amount of damage was reported north of the Virginia Capes.

Tropical disturbance of September 10–15.—Weather conditions over the extreme western Caribbean Sea became disturbed on the 9th and a center was located between Tela and Belize the evening of the 10th. During the next 2 days the disturbance moved very slowly north by east toward Cozumel Island, with gradually increasing intensity; however, after the evening reports of the 12th were received, the direction of movement changed abruptly and the center moved inland over the Yucatan Peninsula north of Payo Obispo. The disturbance then moved west-northwestward across the Peninsula and the southwestern Gulf of Mexico during the next 48 hours, and there was a marked increase in intensity while the disturbance was passing over the Gulf. The center passed directly over Tampico, Mexico, the morning of the 15th. There was a period of calm between 8 a.m. and 10 a.m., and the lowest barometer reading reported was 28.34 inches. Much damage was done in Tampico and vicinity but details are not available.

Northeast storm warnings were ordered displayed at Brownsville, Tex., the evening of the 14th, at which time the indications were that the storm center would reach the coast nearly 100 miles north of Tampico and cause strong northeast winds, possibly reaching gale force at Brownsville. Upon receipt of the morning Tampico report of the 15th in the early afternoon, the warnings at Brownsville were lowered.

Tropical disturbance of September 16–24.—All island stations from St. Kitts to Bridgetown, Barbados, showed a 24-hour decrease in pressure of 0.06 to 0.10 inch the morning of the 14th, indicating the approach of a disturbed condition from the east, but no definite center could be found passing between any of the islands of the Windward and Leewards groups. On the 18th the barometer began to fall slowly at Kingston, Jamaica, and a heavy sea was reported at that place the evening of the 19th. At the same time three vessels about midway between Jamaica and the Isthmus of Panama reported gentle southwest winds and pressure a few hundredths below normal. However, it was not until the evening of the 20th that a center could be located, by which time the disturbance, though of very small diameter, had attained great intensity. The S.S. *President Pierce* in about

latitude 18°50′ N., longitude 83°20′ W., reported a barometer reading of 28.79 inches and a wind velocity of 80 miles per hour from the southwest. A later report received by mail from the S.S. *Virginia* which, at the same time, was close to the position of the *President Pierce* gives the following barometer readings: 6 p.m., 29.65 inches; 7 p.m., 29.49 inches; 8 p.m., 28.78 inches; 8:20 to 8:30 p.m. (in calm center, stars visible), 27.44 inches; 9 p.m., 28.64 inches; 10 p.m., 29.24 inches; 11 p.m., 29.40 inches; midnight, 29.70 inches.

This disturbance moved west by north passing inland over the Yucatan Peninsula with center about 40 miles south of Cozumel Island near midnight of the 21st and into the southwestern Gulf of Mexico north of Campeche the evening of the 22d. The center passed inland a short distance south of Tampico, Mexico, the evening of the 24th, attended by winds of hurricane force. The evening report of the 24th received from the S. S. *J. N. Danziger* was remarkable because of the fact that the vessel was at the time in the center of the storm and reported a wind velocity of only 2 miles per hour and a barometer reading of 28.40 inches. As in the case of the storm of the 15th, great damage was done at and near Tampico, but details are not available.

Tropical disturbance of September 27–October 4.—A minor disturbance apparently moved westward between the islands of St. Kitts and St. Martin on the 27th. It was of such small diameter and slight intensity that the center could not be located definitely every 12 hours. However, available data indicate that it moved westward, until the 29th, when it turned to the north and northeast, passing some distance west of Port au Prince, Haiti, the evening of the 29th and centered north of Puerto Plata, Santo Domingo, the morning of October 1. Still of minor intensity, the disturbance then moved northwestward and later north-northwestward until the 4th, after which it could not be located.

Tropical disturbance of September 28–30.—This was a very minor disturbance that apparently developed northwest of the Isthmus of Panama and moved northwestward. Its center passed near Cape Gracias the evening of the 28th, then traveled west-northwestward and passed inland south of Belize, British Honduras, the morning of the 30th.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING SEPTEMBER 1933

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1932 REVIEW, page 26.

Beginning with this issue, summaries of the total radiation (direct + diffuse) received on a horizontal surface at the Harvard Meteorological Observatory, Blue Hill, Mass. (latitude 42°13′ N., longitude 71°07′ W.; height above sea level, 195 meters), will be regularly included in table 2. Table 4, giving the values of the red and yellow components of the direct solar radiation at this same station, also will be published regularly, beginning with this number.

Table 1 shows that solar radiation intensities averaged above normal for September at all three Weather Bureau stations.

Table 2 shows an excess in the total solar radiation received on a normal surface at all stations for which normals have been computed except Washington, Lincoln, Chicago, New York, and Pittsburgh. It seems significant that the larger cities show a deficiency in the total radiation received coincident with an increased activity in manufacturing, while the smaller cities show an excess in the radiation received.

In table 3 the turbidity values show a clearing of the sky up to noon and a gradual increase in dustiness during the afternoon. On the 19th the sky gradually cleared up to noon after which cumuli formed.

Polarization measurements made on 4 days at Washington give a mean of 56 percent with a maximum of 64 percent on the 18th. At Madison, measurements made on 9 days give a mean of 68 percent with a maximum of 77 percent on the 27th. These values are slightly above normal for September at both stations.

TABLE 1.—*Solar radiation intensities during September 1933*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D.C.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A.M.					P.M.				
	e.	5.0	4.0	3.0	2.0	1.0[1]	2.0	3.0	4.0	5.0	e.
	mm	cal	cal	cal	cal	cal	cal	cal	cal	cal	mm
Sept. 6	13.13					1.24	0.92				10.97
Sept. 7	14.10					1.34					17.37
Sept. 8	19.23					0.97					19.89
Sept. 18	12.24			1.00	1.17	1.41					9.14
Sept. 19	10.21	0.68	0.83	1.01	1.21	1.43					9.83
Sept. 25	14.60					1.33	1.28	1.24			11.81
Sept. 30	10.59			.80	1.00	1.16					9.14
Means		(.68)	(.83)	.94	1.13	1.28	(1.10)	(1.24)			
Departures		−.01	+.08	+.07	+.09	−.03	+.04	+.39			

TABLE 1.—*Solar radiation intensities during September 1933*—Con.

[Gram-calories per minute per square centimeter of normal surface]

MADISON, WIS.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A.M.					P.M.				
	e.	5.0	4.0	3.0	2.0	1.0[1]	2.0	3.0	4.0	5.0	e.
	mm	cal	cal	cal	cal	cal	cal	cal	cal	cal	mm
Sept. 5	12.24			0.90	1.06	1.34					16.20
Sept. 7	14.10	0.38	0.48	.64	.88	1.24					17.96
Sept. 8	14.10	.70	.79	.98	1.14	1.39					12.24
Sept. 12	8.81				1.00						9.14
Sept. 18	7.87	1.00	1.08	1.22	1.33	1.48					7.29
Sept. 19	17.37					1.41	1.30				15.11
Sept. 20	5.79	.91	1.01	1.15							7.57
Sept. 21	7.29	1.02	1.11	1.23	1.37		1.20				7.87
Sept. 23	10.21		.84	.98							12.24
Sept. 27	21.26				1.36	1.55	1.32				5.36
Sept. 28	6.50						1.31	1.12			9.47
Sept. 29	6.27		1.00	1.16	1.30		1.25				6.27
Means		.80	.90	1.03	1.18	1.40	1.27	(1.12)			
Departures		−.06	±.00	+.01	+.03	+.02	+.10	+.10			

LINCOLN, NEBR.

Date	8 a.m. e.	5.0	4.0	3.0	2.0	1.0[1]	2.0	3.0	4.0	5.0	Noon e.
Sept. 1	15.11			0.90	1.08						17.96
Sept. 4	16.79	0.52	0.62	.80	1.04	1.28					16.20
Sept. 5	16.20		.83	.97	1.16		1.17	0.95	0.82	0.73	15.65
Sept. 6	15.11		.91	1.06	1.22	1.42	1.11	.93	.76	.65	12.24
Sept. 7	17.96		.85	.99	1.11			.92	.75	.60	16.20
Sept. 8	16.20	.71	.82	.97	1.17						14.60
Sept. 16	10.97	.94	1.09	1.20	1.34	1.56					7.29
Sept. 18	15.65	.84	.98	1.12	1.20			.93	.77	.65	19.89
Sept. 19	9.47	.53	.76	1.01	1.27	1.57	1.23	1.02	.89	.74	6.50
Sept. 20	6.76	.91	1.01	1.14	1.29	1.57	1.26	1.09	.95	.83	6.76
Sept. 21	8.18			1.04	1.12						12.24
Sept. 22	7.87					1.36	1.17	.97	.83	.70	7.57
Sept. 27	6.02	.81	.86	1.09	1.23	1.46	1.27	1.13	1.00	.91	9.47
Sept. 29	9.83		1.01	1.14	1.31	1.47					6.27
Sept. 30	16.20						1.21	1.06	.92	.80	
Means		.75	.89	1.03	1.20	1.46	1.20	1.00	.85	.80	
Departures		+.06	+.08	+.09	+.09	+.06	+.05	+.03	+.02	±.00	

BLUE HILL, MASS.

Date	8 a.m. e.	5.0	4.0	3.0	2.0	1.0[1]	2.0	3.0	4.0	5.0	Noon e.
Sept. 2	13.6			1.03	1.11	1.30	1.10	0.78			11.0
Sept. 9	18.0						1.24				15.1
Sept. 11	5.6				1.27	1.43					5.0
Sept. 12	6.3				1.33	1.50	1.29				5.6
Sept. 13	6.8					1.46					6.5
Sept. 18	10.6			1.01	1.13	1.47	1.08	.96			8.5
Sept. 19	8.2			1.02			1.25				7.9
Sept. 22	9.8			1.05							9.1
Sept. 23	8.8			1.11		1.51					7.9
Sept. 27	16.2				1.06						17.4
Sept. 30[1]	7.9			1.14	1.24		1.14				10.6
Means				1.06	1.19	1.44	1.18	(.87)			

[1] Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	La Jolla	Gainesville	Miami	New Orleans	Riverside	Blue Hill
	Gram calories per square centimeter														
1933	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	427	445	519	392	310	584	275	232	557	423	336	464	431	542	324
Sept. 10	176	193	247	168	267	579	190	218	468	247	365	556	406	489	328
Sept. 17	437	398	487	378	315	565	321	142	438	353	395	487	399	512	469
Sept. 24	392	240	409	242	343	495	308	134	386	272	428	470	397	373	289
	Departures from weekly normals														
Sept. 3	+40	+66	+59	+67	−13	+40	−63	....	+34	+82	−6	−2	....	....	....
Sept. 10	−193	−148	−175	−133	−45	+61	−149	....	−34	−59	+21	+84	....	....	....
Sept. 17	+79	+54	+72	+87	+16	+75	−29	....	+48	+52	+17	+11	....	....	....
Sept. 24	+40	−51	+29	−21	−39	+55	−26	....	+74	−34	+49	+7	....	....	....
	Accumulated departures on September 30														
	+6,944	−1,869	+3,885	+12,397	+8,099	+8,715	−1,666	....	+707	+9,226	....	−4,102	....	....	....

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric-turbidity factor, β, Washington, D.C., September 1933*

[Values in italics have been interpolated]

Date and solar-hour angle	Solar altitude, h.		Air mass, m.	I_m	I_y	I_r	β	Blueness of sky	Atmospheric dust particles per cubic centimeter	Notes: Skylight polarization, P., clouds, etc.
1933										
Sept. 7	°	′		gr. cal.	gr. cal.	gr. cal.				
0:33a	56	19	1.20	1.283	*0.870*	0.690	0.110			
0:30a	56	30	1.20	1.243	0.875	*0.695*	0.140	......	292	
Sept. 18										
4:44a	18	19	3.16	0.919	*0.691*	0.569	0.075			
4:36a	19	51	2.93	1.011	*0.696*	0.572	0.055			
4:17a	23	35	2.49	1.097	0.754	*0.590*	0.040			
4:12a	24	26	2.40	1.112	0.757	*0.593*	0.035			
3:28a	32	37	1.86	1.198	*0.856*	0.653	0.025	6	605	P=64.0%
3:41a	40	40	1.53	1.348	*0.884*	0.761	0.085			
2:38a	41	12	1.52	1.348	0.885	*0.761*	0.082			
0:38a	55	40	1.20	1.380	0.897	*0.758*	0.080			
0:34a	55	54	1.20	1.361	*0.900*	0.761	0.090			
Sept. 19										
4:54a	14	30	3.94	0.848	*0.680*	0.532	0.065			
4:47a	15	38	3.68	0.894	0.683	*0.535*	0.055			
4:27a	19	40	2.95	1.018	0.744	*0.590*	0.040			
4:22a	20	30	2.84	1.045	*0.747*	0.593	0.038			
4:09a	22	58	2.55	1.110	*0.775*	0.614	0.030			
4:05a	23	44	2.48	1.125	0.778	*0.619*	0.032	6	485	P=59.8%
2:19a	41	44	1.50	1.299	0.911	*0.611*	0.020			
2:14a	42	18	1.48	1.259	*0.912*	0.614	0.020			

TABLE 4.—*Solar radiation measurements obtained at the Blue Hill Meteorological Observatory of Harvard University, during September 1933.*

Date and Solar Hour Angle.	Solar altitude. h.		Air mass. m	I_m	I_y	I_r	Sky conditions;—(clouds, haze (hz), smoke (smk), visibility (v, international scale), wind, etc.).
Sept. 2	°	′		gr. cal.	gr. cal.	gr. cal.	
3:27, a.m.	33	08	1.73	1.142	0.833	0.653	Few Ci; hz 6°-8°; v 6; W=2
3:02, a.m.	37	11	1.65	1.185	0.858	0.670	
1:18, a.m.	51	47	1.27	1.256	0.894	0.698	Few Ci; hz to 6°; v 7; W-1
0:23, p.m.	55	36	1.21	1.207	0.847	0.675	
3:14, p.m.	35	41	1.71	1.082	0.797	0.634	2 Cu, few Ci; hz to 4°; v 6-7
4:49, p.m.	18	26	3.14	0.720	0.578	0.461	6 Ci, few Cu; v 6-7; SW-2.
Sept. 12							
3:47, a.m.	27	00	2.19	1.310	0.961	0.767	
3:01, a.m.	34	40	1.73	1.358	0.987	0.784	Few Ci in SE, Acu in SE; v 6-8; W-2.
0:20, a.m.	51	42	1.27	1.444	1.013	0.797	Few Ci; lt hz; v 9; WSW-4.
1:34, p.m.	46	35	1.38	1.384	0.974	0.774	Few Ci; lt hz; v 9-10; W-4.
Sept. 13							
1:06, p.m.	48	53	1.34	1.401	0.960	0.752	7 Ci; v 9; W-3.
Sept. 19							
4:12, a.m.	20	45	2.81	1.034	0.776	0.634	1 Acu; lt hz; v 8-9; W-5.
Sept. 22							
4:07, a.m.	20	17	2.86	1.060	0.784	0.629	1 Acu; lt hz; v 8; WNW-4.
Sept. 23							
4:04, a.m.	21	00	2.77	1.164	0.875	0.703	1 Acu in SW, few in NE; lt hz; v 8-9; W-3.
1:30, a.m.	43	06	1.45	1.409	1.009	0.784	2 Ci, Cicu; lt hz; v 9; WNW-3.
Sept. 27							
2:43, p.m.	32	49	1.84	0.926	0.672	0.500	9 Cist, 1 Acu; v 7; S-4.
Sept. 30							
2:19, a.m.	34	56	1.74	1.264	0.908	0.703	1 Ci, Cist; hz to 3°; v 6-8; WNW-2
0:55, a.m.	43	16	1.45	1.246	0.890	0.690	Few Cu, Acu, in E; hz to 3°-4°; v 8; S-2
0:51, p.m.	43	25	1.45	1.295	0.886	0.694	3 Cu, Frcu; lt hz; v 8-9; SSW-2.
2:58, p.m.	29	40	2.02	1.130	0.819	0.632	Few Cu; lt hz; v 9; S-3.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time		Heliographic: Diff. long.	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day
1933	h	m	°	°	°			
Sept. 1 (Naval Observatory)	....			No spots		......	......	......
Sept. 2 (Naval Observatory)	14	6		No spots		......	......	......
Sept. 3 (Naval Observatory)	12	21		No spots		......	......	......
Sept. 4 (Perkins Observatory)	11	30		No spots		......	......	......
Sept. 5 (Naval Observatory)	11	24		No spots		......	......	......
Sept. 6 (Naval Observatory)	13	42	+18.0	48.6	−12.0	......	93	93
Sept. 7 (Naval Observatory)	11	29	+31.0	49.6	−11.0	......	77	77
Sept. 8 (Naval Observatory)	12	10	+43.0	48.0	−10.5	......	62	62
Sept. 9 (Naval Observatory)	11	2	+56.5	48.9	−10.5	......	40	40
Sept. 10 (Naval Observatory)	11	34	+70.0	48.9	−10.5	......	12	12
Sept. 11 (Naval Observatory)	11	15		No spots		......	......	......
Sept. 12 (Mount Wilson)	9	40		No spots		......	......	......
Sept. 13 (Mount Wilson)	10	1		No spots		......	......	......
Sept. 14 (Mount Wilson)	9	26		No spots		......	......	......
Sept. 15 (Mount Wilson)	9	52		No spots		......	......	......
Sept. 16 (Perkins Observatory)	14	25		No spots		......	......	......
Sept. 17 (Naval Observatory)	12	2		No spots		......	......	......
Sept. 18 (Naval Observatory)	12	28		No spots		......	......	......
Sept. 19 (Naval Observatory)	12	29		No spots		......	......	......
Sept. 20 (Naval Observatory)	12	17		No spots		......	......	......
Sept. 21 (Naval Observatory)	14	22	−13.0	179.2	+14.0	......	25	25
Sept. 22 (Naval Observatory)	13	10	−1.0	178.6	+13.0	......	15	15
Sept. 23 (Naval Observatory)	11	27	+13.0	180.4	+14.0	15	......	15
Sept. 24 (Naval Observatory)	12	34		No spots		......	......	......
Sept. 25 (Naval Observatory)	11	35		No spots		......	......	......
Sept. 26 (Naval Observatory)	14	23		No spots		......	......	......
Sept. 27 (Naval Observatory)	11	12		No spots		......	......	......
Sept. 28 (Naval Observatory)	12	17	+24.0	124.9	−1.0	......	19	19
Sept. 29 (Naval Observatory)	11	1	+37.0	125.4	−1.5	......	15	15
Sept. 30 (Naval Observatory)	11	42	+49.0	123.9	−1.0	......	12	12
Mean daily area for September	......		......	......	......	......	......	13

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR SEPTEMBER 1933

(Dependent alone on observations at Zurich and its station at Arosa)

[Observations furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Switzerland]

September 1933	Relative numbers	September 1933	Relative numbers	September 1933	Relative numbers
1	0	11	0	21	7
2	7	12	0	22	....
3	7	13	0	23	11
4	7	14	0	24	8
5	0	15	0	25	0
6	Mc 15	16	0	26	0
7	19	17	0	27	0
8	12	18	0	28	11
9	11	19	....	29	12
10	7	20	0	30	8

c=New formation of a center activity; M, in the central zone.

Mean: 28 days=5.1.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

[Aerological Division, W. R. Gregg in charge]

Free-air temperatures were above normal during September in practically all cases (see table 1). The largest departures occurred at Cleveland and Omaha where they reached considerable magnitude. Most free-air relative humidity departures were negative and of only moderate magnitude.

Resultant free-air wind velocities exceeded the normals at most stations (see table 2). Resultant free-air wind directions were close to normal except in the southern part of the country where an excess of southerly winds prevailed.

TABLE 1.—*Free-air temperatures and relative humidities obtained by airplanes during September 1933*

TEMPERATURE (° C.)

Altitude (meters) m.s.l.	Cleveland, Ohio (246 meters) [1]		Dallas, Tex. (146 meters) [2]		Norfolk, Va. (3 meters) [3]		Omaha, Nebr. (300 meters) [4]		Pembina, N.Dak. (254 meters) [5]		Pensacola, Fla. (2 meters) [3]		San Diego, Calif. (9 meters) [3]		Washington, D.C. (2 meters) [3]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	15.7	(6)	23.6	(6)	22.3	−0.7	17.3	(6)	10.8	(6)	24.9	+0.7	16.9	−2.9	19.1	−1.5
500	18.4	(6)	25.4	(6)	21.4	−0.1	18.8	(6)	13.1	(6)	23.7	+0.6	14.4	−2.2	19.8	+0.5
1,000	17.0	+2.3	23.4	+3.7	19.5	+0.4	20.9	+4.6	12.7	+1.8	21.4	+0.8	17.3	−1.5	18.5	+0.9
1,500	14.7	+2.8	20.5	+3.1			19.7	+5.6	10.4	+1.5						
2,000	12.6	+3.2	17.4	+2.6	13.4	0.0	17.2	+5.8	7.6	+1.1	14.5	−0.4	19.6	+2.0	13.0	+0.1
2,500	10.8	+4.0	14.6	+2.3			14.2	+5.9	4.3	+0.4						
3,000	8.6	+4.2	11.5	+1.8	8.2	+0.2	11.1	+5.9	1.3	+0.2	8.5	−0.8	13.7	+1.9	8.7	+0.6
4,000	3.2	+4.3	6.8	+2.7			4.9	+5.5	−4.8	−0.5	3.1	−0.7	7.2	+1.9	3.0	+0.8
5,000	−2.8	+5.0	1.3	+2.5			−1.6	+4.4	−11.0	−0.8	−2.5	−0.7				
RELATIVE HUMIDITY (PERCENT)																
Surface	83	(6)	86	(6)	76	+1	86	(6)	78	(6)	84	−2	81	+7	78	+3
500	66	(6)	72	(6)	65	−2	76	(6)	68	(6)	77	−3	86	+5	65	−2
1,000	62	−3	68	−2	56	−7	56	−3	61	+2	70	−5	63	+6	60	−2
1,500	61	−2	68	+5			51	−5	57	+2						
2,000	57	−2	70	+12	54	−7	49	−5	57	+4	69	0	28	−2	62	+3
2,500	48	−8	64	+12			48	−7	57	+4						
3,000	40	−12	64	+16	44	−8	47	−7	55	+2	60	−1	26	+1	56	+4
4,000	41	−6	55	+15			41	−10	48	−1	51	−3	23	+1	51	+3
5,000	40	−4	49	+13			39	−10	40	−7	46	−4				

[1] Temperature departures based on normals determined by extrapolating latitudinally those of Royal Center, Ind., and Due West, S.C. Humidity departures based on those of Royal Center, Ind.

[2] Temperature departures based on normals determined by interpolating latitudinally those of Groesbeck, Tex., and Broken Arrow, Okla. Humidity departures based on normals of Groesbeck, Tex.

[3] Naval air stations.

[4] Temperature and humidity departures based on normals of Drexel, Nebr.

[5] Temperature departures based on normals determined by extrapolating latitudinally those of Ellendale, N.Dak., and Drexel, Nebr. Humidity departures based on those of Ellendale, N.Dak.

[6] Surface and 500-meter level departures omitted because of difference in time of day between airplane observations and those of kites upon which the normals are based.

Weather Bureau observations made near 5 a.m.; Navy observations near 7 a.m., e.s.t.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a.m. (E.S.T.) during September 1933*

[Wind from N=360°, E=90°, etc.]

Altitude (meters) m.s.l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Bismarck, N.Dak. (518 m)		Brownsville, Tex. (12 m)		Burlington, Vt. (132 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cleveland, Ohio (245 m)		Dallas, Tex. (154 m)		Havre, Mont. (762 m)		Jacksonville, Fla. (14 m)		Key West, Fla. (11 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	353	0.7	334	0.9	231	0.3	113	1.1	174	1.5	281	2.2	199	1.0	212	1.6	161	2.2	249	1.8	284	0.6	111	3.0
500			329	1.6			130	4.9	225	3.2			259	2.9	260	3.8	196	9.0			262	.9	110	6.0
1,000			346	.4	261	4.1	138	5.1	279	4.1			277	6.6	285	6.4	207	8.9	257	4.0	128	.7	111	5.7
1,500			347	2.8	260	6.1	131	5.2	294	5.9			280	8.8	282	7.8	206	5.9	272	6.2	90	.7	101	5.5
2,000	195	2.1	7	2.1	268	7.8	118	5.3	293	8.1	259	3.9	292	9.2	277	10.0	202	2.0	269	8.1	92	.8	114	4.9
2,500	257	2.6	351	1.5	276	8.8	109	5.2	291	9.8	257	7.2	269	10.5	275	10.6	179	1.2	272	9.5	139	1.2	114	4.6
3,000	253	4.1	339	1.9	281	9.2	111	5.4	285	10.9	267	8.5			261	9.9	186	.4	275	10.1	201	.3	111	4.9
4,000	236	4.0	312	2.4			88	4.0			268	11.8			256	11.6	204	1.4	264	11.1	270	1.2	93	5.7
5,000	239	3.8	303	4.7			69	2.5			271	8.4					58	.8	232	7.4	270	1.5	91	4.7

Altitude (meters) m.s.l.	Los Angeles, Calif. (217 m)		Medford, Oreg. (410 m)		Memphis, Tenn. (83 m)		New Orleans, La. (2 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Phoenix, Ariz. (338 m)		Salt Lake City, Utah (1,294 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Washington, D.C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	187	0.3	355	0.2	184	0.9	36	6.1	95	0.9	180	4.2	163	0.9	98	2.2	151	3.4	77	0.3	141	2.3	285	0.6
500	77	.6	329	.4	223	4.8	114	2.4	316	2.0	180	7.3	208	3.2	113	1.4			166	1.4	204	6.1	284	5.6
1,000	354	1.7	288	1.2	233	4.9	131	3.7	338	2.7	215	12.0	244	7.4	226	1.6			259	4.5	222	6.9	284	6.6
1,500	249	1.3	192	1.1	246	3.8	129	4.4	315	2.1	227	8.2	261	6.4	233	1.8	169	4.8	268	6.4	218	6.2	292	8.1
2,000	233	2.2	235	3.4	254	3.3	127	4.0	302	2.8	247	5.5	257	5.9	209	2.1	192	4.3	271	6.7	226	3.7	287	9.8
2,500	227	2.7	252	5.5	261	2.3	138	2.8	284	3.5	245	4.1	255	7.4	197	2.9	220	5.4	278	8.3	241	4.3	286	9.6
3,000	195	3.5	242	6.6	270	2.2	124	1.9	269	3.0	243	2.8	264	7.5	180	3.8	237	7.5	282	10.2			291	10.0
4,000			251	8.3	261	3.4	110	1.8			90	.9	238	6.7	191	5.0	257	10.2	283	12.9			288	13.0
5,000			286	5.7											172	4.5	271	10.9						

RIVERS AND FLOODS

By RICHMOND T. ZOCH

[River and Flood Division, Montrose W. Hayes in charge]

During September minor to moderate floods occurred in the rivers of the Southeastern States, in scattered places over the Mississippi Basin, and in the Rio Grande.

Unusually heavy and general rains on September 1, over the watershed of the Big Sioux River, caused a flood, the estimated damage from which was $322,000. This flood attracted considerable interest because of the prolonged dry spell, which has prevailed during the last 4 years. While the need for the repletion of ground water supply was badly felt, the run-off was so rapid that the soil did not absorb the rain to a very great extent and the subsoil remained almost as deficient in moisture as before the rain.

Moderate to heavy general rains over the San Juan watershed in Mexico from the hurricanes which passed inland at Brownsville, Tex., on September 4–5 and at Tampico, Mexico, on September 15 and September 24, caused above flood stages in the Rio Grande from Riogrande, Tex., to its mouth during the greater part of September. No lives were lost in the high waters and very little property of any kind was damaged.

As stated in the August issue of the REVIEW, a severe flood occurred in Cherry Creek near Denver, Colo. Mr. J. M. Sherier, the official in charge of the Denver, Colo., Weather Bureau office, writes as follows about this flood:

Owing to excessive rains in the eastern portion of Douglas County on the night of August 2–3, 1933, the Castlewood Dam, located on Cherry Creek about 32 miles southeast of Denver, collapsed shortly after midnight of the 3d. In the flood which resulted, the crest of which reached Denver about 7:30 a.m. of the 3d, 2 persons were drowned, hundreds of acres of fertile farm lands were ruined, scores of head of livestock were lost, and many bridges, including 6 within the city limits of Denver, were destroyed. Basements of hundreds of houses in the lower portion of Denver were flooded, and water completely filled the subway of the Union Station and reached a depth of a foot and a half in the main waiting room.

According to a recent survey by a committee of engineers, the estimated damage within the city was as follows: Residential property, $64,147; industrial property, $439,143; railroads, $65,450; city of Denver, $175,000. Outside of the city the following damages are estimated by the same committee to have resulted: Farm property, $159,000; industrial property, $18,550; railroads, $8,000; bridges, $24,500. In all 1,100 pieces of property were reported to have been involved, and the total amount of the damage is estimated to have been $953,790.

On account of the timely warnings by the caretaker at the dam, and the action by city and county officials and telephone companies in giving the information thorough distribution, hundreds of lives undoubtedly were saved.

At the present time steps are being taken to form a conservancy district and to construct permanent safeguards against disasters of this kind. Under ordinary conditions Cherry Creek is a tiny stream that trickles and meanders through the valley above Denver, and its bed through the city itself, between concrete retaining walls, often is dry. It rises, however, in a region that is subject to violent downpours. The Indians are said to have called it "a bad actor", a reputation which it has maintained through all of the years since their time.

Table of flood stages for September 1933

[All dates in September unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
Waccamaw: Conway, S.C	7	7	19	8.4	8
Saluda: Chappells, S.C	14	7	9	18.0	8
Santee:					
Rimini, S.C	12	1	17	15.0	10, 12
		19	24	13.1	22-33
		27	(*)	13.2	30
Ferguson, S.C	12	10	18	12.4	13-16
Savannah: Ellenton, S.C	14	9	11	14.7	10
Ogeechee: Meldrim, Ga	9	7	14	10.7	8
Altamaha: Everett City, Ga	10	10	13	10.8	11
MISSISSIPPI SYSTEM					
Missouri Basin					
Big Sioux: Akron, Iowa	12	3	7	17.6	5
Grand:					
Gallatin, Mo	20	27	28	21.3	27
Chillicothe, Mo	18	28	28	20.5	28
Ohio Basin					
West Fork: Anderson, Ind	8	27	28	9.3	28
Wabash:					
Bluffton, Ind	10	29	Oct. 1	11.1	29
La Fayette, Ind	11	29	29	11.7	29
Arkansas Basin					
Arkansas:					
Arkansas City, Kans	15	2	3	16.0	3
Fort Smith, Ark	22	5	5	22.4	5
WEST GULF OF MEXICO DRAINAGE					
Rio Grande:					
Riogrande, Tex	21	7	9	31.9	8
		17	18	24.5	17
Hidalgo, Tex	22	9	11	25.2	10-11
		19	20	22.7	19
Mercedes, Tex	20	7	13	22.0	10-11
		18	27	21.7	19-20
Brownsville, Tex	18	8	15	18.7	9
		19	29	18.4	22, 26

* Continued into October.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, W. F. McDonald in charge]

NORTH ATLANTIC OCEAN

By W. F. McDONALD

Atmospheric pressure.—Average pressures during September 1933 were above normal over the northeastern Atlantic and western Europe. The largest excess was a quarter of an inch, in the region of the Shetlands. High pressure areas were better developed and more persistent from the Azores northeastward than in other regions of the North Atlantic. The highest barometer readings of the month were observed southeast of Ireland between the 6th and 8th when a number of ships recorded 30.40 to 30.60 inches.

Considering the month as a whole, however, the normal Atlantic HIGH was characterized by weakness and irregularity, especially between the 3d and 10th, and from the 22d until the close. When well established, the center was at times shifted unusually far south of the Azores, and on several dates between the 9th and 17th the barometer was up to 30.00 inches in latitudes as low as 5° N., which is an abnormal height for that region of the Atlantic.

Average pressures were 0.10 to 0.20 inch below normal along the American coast north of Cape Hatteras, and slightly deficient over the remainder of the ocean west of a line from the Madeiras to southeast Greenland.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, September 1933*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.59	-------	30.16	10	29.06	17
Reykjavik, Iceland	29.80	+0.08	30.32	13	29.20	16
Lerwick, Shetland Islands	30.10	+.26	30.54	7	29.52	18
Valencia, Ireland	30.06	+.07	30.42	7	29.48	23
Lisbon, Portugal	30.06	+.04	30.39	21	29.79	14
Madeira	30.05	+.03	30.36	6	29.83	16
Horta, Azores	30.14	−.03	30.30	13	29.94	16
Belle Isle, Newfoundland	29.75	−.15	30.24	25	28.78	11
Halifax, Nova Scotia	29.89	−.16	30.40	16	28.90	18
Nantucket	29.90	−.18	30.28	15	29.16	17
Hatteras	29.93	−.13	30.20	3	28.26	16
Bermuda	30.04	−.04	30.18	3, 4	29.76	10
Turks Island	29.93	−.05	30.02	8, 18	29.80	2, 30
Key West	29.90	−.04	30.07	8	29.61	1
New Orleans	29.94	−.04	30.11	9	29.80	11
Cape Gracias, Nicaragua	29.79	−.04	29.86	7, 8	29.68	30

NOTE.—All data based on a.m. observations only, with departures compiled from best available normals related to time of observations, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—Extratropical low-pressure areas were slow moving, as a rule, and persistently dominated the region from Hudson Bay to mid-Atlantic as far as the thirtieth meridian but seldom moved on eastward into the Greenland Sea. Several lows, however, moved from the Atlantic into western Europe.

Gales infrequently attended extratropical cyclones along the higher latitudes, and were reported at scattered places north of the fortieth parallel on less than one third of the days of the month. Between the 15th and 22d, however, gales and hurricane winds were experienced by many ships in connection with a tropical disturbance that had moved into latitudes above 40°, first along the American coast but finally in the region southwest of Iceland as the hurricane center merged with other low-pressure systems of the high latitudes and traveled northeastward across the Atlantic. (See table of gales.) The whole track for this storm preceding September 22 is shown on chart XI.

Several cyclones developed over the Atlantic between the Azores and the American coast, but only one produced storm conditions deserving of mention. That disturbance began about the 23d southwest of the Azores, and moved steadily northward, attended by whole gales over a narrow track that started near latitude 30° on the 24th and extended almost to latitude 55° by the 27th. The origin in this case appears to have been definitely extratropical, but the storm exhibited some of the characteristics of a small tropical cyclone in its type of movement and the limited area of strong winds.

South of latitude 40° and west of the sixty-fifth meridian, the month of September was productive of an extraordinary number of ships' gale reports, all resulting from the activity of tropical cyclones.

Tropical cyclones.—Seven cyclonic disturbances were recognized in the West Indian region in September 1933, as discussed elsewhere in this issue, but only five of these produced gale winds reported by ships.

A hurricane of major intensity was in progress westward along the north coast of Cuba at the opening of the month. The American steamers *La Perla* and *Betterton* experienced hurricane winds on the afternoon of September 1 in the Florida Straits, and on the 2d the *Harvester* had force 12 and a barometer of 27.99 inches near 25° N., 86° W. After that date, winds of force 10 to 11 were the highest reported by ships in the Gulf as the storm moved steadily westward and passed inland near Brownsville on the night of September 4. Damage to maritime interests by this hurricane was mostly confined to the north coast of Cuba and the southern coast of Texas.

While this hurricane was in full progress over the Florida Straits, another was forming some distance north of Puerto Rico. About midnight of September 1 its center, accompanied by storm winds (force 11) shifting from west-northwest to south, passed near the American tanker *Gulfwing*, at 22° N., 69° W., where the barometer fell to 28.89 inches. From that date until the 6th, vessels experienced strong gales and storm winds associated with the further movement of this disturbance over the northern Bahamas to Florida and Georgia, but so far no ship has reported winds of hurricane force, in that connection.

The weather chart for September 4 (chart VIII) shows the first of these storms approaching Brownsville, with the second over Florida.

On the afternoon of September 11, the major hurricane of the month was definitely identified with its center fully developed near 23° N., 62° W., where the French steamship *Washington* passed through the left semicircle. The barometer fell to 27.96 inches, attended by winds of force 11 shifting from north-northwest to southwest. The vortex was of relatively small diameter at the time, for at the same hour when the *Washington* experienced the lowest pressure the British steamship *Tuscarora*, then about 50 miles away, recorded a barometer reading of 29.53 inches.

No ship has reported coming in close contact with the center of this hurricane again until the 15th, although winds of force 9 to 11 were recorded by several ships at distances of 75 to 100 miles on either side of the storm track. On the morning of the 15th the American ship *Orizaba* experienced a southeast hurricane, barometer 28.59, near 34° N., 74° W. Thereafter the marine records are replete with ships' observations of pressures between 28.24 and 29.00 inches, and winds of hurricane

violence, as the storm center moved northward past Cape Hatteras and thence northeastward to Nova Scotia. The details of the more intense phases of this movement will be found in the selections from the numerous ships' reports carried in the accompanying table of gales and storms.

The situation over the Atlantic on September 15, when this hurricane fully covered the coastwise steamer lanes, is shown on chart IX; and its stage 3 days later on chart X. The complete track of the storm, after it had passed on toward Iceland, will be found on chart XI. Notwithstanding its great size and intensity, and the course northward over crowded shipping lanes, there was remarkably little maritime loss apart from the damage to coastal works and small craft.

While this major storm was in progress two other intense disturbances arose in the western Caribbean Sea, at dates less than 10 days apart, which followed remarkably similar tracks northwestward across Yucatan and the Gulf of Campeche. Each struck Tampico, Mexico, as a disastrous hurricane. The first of these storms produced gales of force 9 in the Gulf of Honduras on the 12th and 13th, and whole gales in the southwestern Gulf of Mexico, on the 14th and 15th, but so far no ship has reported winds of hurricane force.

The second of the pair was of hurricane intensity over a very small area when the center was first definitely located by the American liner *Virginia*, which passed through the vortex (pressure 27.40 inches) at 18°30′ N., 83° W., on September 20. This experience of the *Virginia* is fully reported in another place in this issue. On the following day the American steamer *Tivives* also experienced hurricane winds in this storm as she was steering northward into the Yucatan Channel. Again, however, the center moved through the southwestern Gulf without seriously involving any of the small number of vessels that ply those waters, and no winds higher than force 10 have been reported from that region prior to September 24, when the center moved in over Tampico.

Storm damage in the city of Tampico was very great, both in property and in human lives, but no major loss to shipping has come to notice. The German steamer *Adria* reports that the two storms caused great changes in the entrance to Tampico harbor by the action of storm tides and currents, which shifted the bar.

Chart IX shows the first of these two storms over Tampico. The second is shown over Yucatan on chart XI.

Fog.—Fogginess was less prevalent than usual near the European coast, and above average frequency west of the 20th meridian. The normal seasonal decrease did not occur in the region of the Grand Banks and Gulf of Maine, where fogs were encountered on 10 to 14 days of the month, nor in the surrounding regions from Cape Hatteras to mid-Atlantic north of the 40th parallel, where fogginess was reported on 6 to 9 days in many 5-degree squares.

Fog occurred September 14 on the 25th parallel south of the Canary Islands; this is a most unusual record.

OCEAN GALES AND STORMS, SEPTEMBER 1933

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ALTANTIC OCEAN			° ′	° ′				Inches					
La Perla, Am.S.S.	Baltimore	Puerto Barrios.	24 20 N	80 40 W	Sept. 1	5p., Sept 1.	Sept. 2	29.51	ENE	ESE, 12	SE	ESE, 12	None.
Cefalu, Hond.S.S.	Habana	Cristobal	23 09 N	82 21 W	do	5p., 1	Sept. 1	29.06	NNE	W, 10	SSE	W, 10	WNW-SSW.
Betterton, Am.S.S.	Houston	New York	24 20 N	82 40 W	do	6p., 1	Sept. 2	29.41	NE	NE, 12	ESE	NE, 12	NE-E.
Gulfwing, Am.M.S.	Las Piedras, Venezuela.	Philadelphia	21 52 N	68 59 W	do	11p., 1	do	28.89	N	W, 11	SE	W, 11	WNW-W-S.
William G. Warden, Am.S.S.	Port Aransas	Baltimore	24 45 N	83 45 W	do	1a., 2	do	29.37	NE	E, 11	ESE	E, 11	E.
Dilworth, Am.S.S.	New York	Colon	25 28 N	74 00 W	Sept. 2	1p., 2	Sept. 3	29.46	E	NE, 10	SE	do	NE-E.
Harvester, Am.S.S.	Houston	New York	25 00 N	86 00 W	do	2p., 2	do	27.99	NE	NE, 12	do	NE, 12	NE-E-SE.
Pacific Sun, Am.M.S.	Beaumont	Marcus Hook	25 59 N	85 38 W	do	4p., 2	Sept. 2	29.71	do	ENE, 10	ESE	ENE, 11	NE-ENE-E.
Bremen, Ger.S.S.	New York	Bremerhaven	41 47 N	52 34 W	Sept. 1	8p., 2	do	29.79	ESE	NNE, 10	do	NNE, 12	SSE-N-ESE.
Trimountain, Am.S.S.	Philadelphia	Cristobal	25 00 N	73 30 W	Sept. 2	8p., 2	Sept. 3	29.69	ENE	Var., 11	SSE	Var., 11	ENE-SSE.
Aldecoa, Span.S.S.	Lisbon	New York	40 32 N	51 48 W	do	Mdt., 2	do	29.83	S	SSW, 10	NNW	SSW, 10	S-WSW-NW.
El Mundo, Am.S.S.	Galveston	do	27 40 N	91 00 W	Sept. 3	1p., 3	do	29.59	N	NE, 9	ESE	NE, 9	NE-E.
R. J. Hanna, Am.S.S.	Houston	Marcus Hook	25 30 N	93 00 W	do	8p., 3	Sept. 4	29.20	do	W, 11	SSE	WSW, 11	NW-W-WSW.
Berlin, Ger.S.S.	English Channel.	New York	48 47 N	28 10 W	Sept. 4	7p., 4	Sept. 5	29.68	SSE	S, —	NW	NW, 9	S-W-NW.
Hazelwood, Br.S.S.	Swansea	Montreal	53 39 N	24 06 W	do	2a., 5	Sept. 7	29.17	S	S, 6	S	WNW, 10	S-WSW-WNW.
Gonzenheim, Ger.S.S.	Botwood	Antwerp	50 57 N	48 45 W	do	4a., 6	Sept. 6	29.40	SW	SSW, 8	W	SSW, 9	
Solana, Am.S.S.	Boston	New Orleans	31 25 N	80 06 W	Sept. 5	4a., 6	do	29.63	SE	S, 9	S	S, 9	SE-SSE-S.
Quistconck, Am.S.S.	Hamburg	Norfolk	42 24 N	55 54 W	Sept. 10	Mdt., 10	Sept. 11	29.21	SW	SW, 8	W	SW, 10	None.
Hazelwood, Br.S.S.	Swansea	Montreal	52 25 N	52 48 W	Sept. 11	6p., 11	Sept. 13	29.07	SSE	ESE, 6	WSW	S, 9	S-ESE-WSW.
Washington, Fr.M.S.	Cristobal	Havre	23 15 N	61 40 W	Sept. 10	8p., 11	Sept. 12	27.96	NE	NNW, 11	SSE	SW, 11	NNW-SW.
Tuscarora, Br.S.S.	Aruba	Liverpool	22 52 N	61 20 W	Sept. 11	8p., 11	do	29.53	NNW	WSW, 9	SE	S, 10	W-WSW-SSW.
Zacapa, Am.S.S.	Tela, Honduras.	New Orleans	18 05 N	87 06 W	Sept. 12	4a., 12	Sept. 13	29.39	NW	NW, 6	do	SE, 9	
President Hayes, Am.S.S.	Habana	Cristobal	20 15 N	84 18 W	do	4p., 12	do	29.70	NE	ESE, 8	do	ESE, 9	SSE-E-SE.
Sinaloa, Hond.S.S.	Mobile	Bluefield	[1]18 34 N	86 58 W	do	2a., 13	do	29.43	E	ESE, 9	do	SE, 9	ESE-SE.
Panuco, Am.S.S.	New York	Progreso	21 30 N	89 30 W	Sept. 13	5p., 13	Sept. 14	29.40	NE	ENE, 7	do	ESE, 8	ENE-ESE.
Gulfstar, Am.S.S.	Las Piedras, Venezuela.	New York	28 54 N	69 50 W	do	1a., 14	do	29.61	do	SE, 10	SSE	SE, 10	ESE-SE.
Spondilus, Br.M.S.	Tuxpam, Mexico.	Rotterdam	22 26 N	93 37 W	do	4a., 14	Sept. 15	29.48	do	E, 10	SE	E, 10	ENE-E.
Thomas H. Wheeler, Am.S.S.	Portland, Maine.	Baytown	30 50 N	76 40 W	Sept. 14	7p., 14	do	29.52	do	NW, 9	W	NW, 9	NW-W.
Anderson, Nor. S.S.	Tuxpam	New Orleans	[1]23 12 N	95 48 W	do	Mdt., 14	do	29.12	NW	E, 6	ESE	E, 10	NNE-E-SE.
Orizaba, Am.S.S.	New York	Habana	33 30 N	74 00 W	do	8a., 15	Sept. 16	28.59	ENE	SE, 11	SW	SE, 12	ESE-SE.
El Oceano, Am.S.S.	do	Galveston	34 00 N	74 30 W	Sept. 15	Mdt., 15	do	28.24	do	S, 5	WSW	ENE, 11	SSW.
Shenandoah, Am.S.S.	Norfolk	Port Arthur	36 35 N	75 00 W	do	2p., 16	Sept. 17	28.43	E	ENE, 12	WNW	NW, 12	ENE-NNW.
Gulfcrest, Am.M.S.	New York	Cristobal	37 40 N	73 40 W	Sept. 16	3p., 16	do	28.65	NE	NE, 10	W	ENE, 10	ENE-N-NW.
Veragua, Am.S.S.	do	Habana	36 48 N	74 54 W	do	4p., 16	Sept. 16	28.65	ESE	N, 12	NW	N, 12	NNE-N-NW.
Gulfhawk, Am.M.S.	Philadelphia	Las Piedras	36 48 N	74 38 W	do	4p., 16	do	28.66	E	E, 12	WNW	E, 12	E-N-NW.
Gulf of Mexico, Am.S.S.	New York	Port Arthur	36 35 N	74 41 W	Sept. 15	6p., 16	do	28.48	SE	NNW, 10	NW	ESE, 11	ENE - NNW-NW.
Nitro, U.S.N.	Hampton Roads.	Habana	36 14 N	73 12 W	do	7p., 16	Sept. 17	29.24	ENE	SSE, 11	W	SSE, 12	SSE-S.
Walter Jennings, Am.S.S.	New York	Baytown	[1]37 12 N	74 18 W	Sept. 16	9p., 16	do	28.90	E	NE, 12	WNW	NNE, 12	NE - NNE-NNW.

[1] Position approximate.

OCEAN GALES AND STORMS, SEPTEMBER 1933—Continued

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
			° ′	° ′				Inches					
Monarch of Bermuda, Br.M.S.	New York	Bermuda	39 15 N	72 42 W	Sept. 16	7a., 17	Sept. 17	28.85	NE	NW, 10	WSW	ENE, 12	ENE - NW - WNW.
James McGee, Am.S.S.	Boston	Galveston	37 18 N	69 15 W	do	7a., 17	do	29.34	SE	SSW, 10	do	S, 10	SSE-S-SSW.
Jean Jadot, Belg.S.S.	Antwerp	New York	40 03 N	71 50 W	Sept. 17	10a., 17	do	29.13	E	N, 10	WNW	N, 11	NNE-N-NNW.
Bremen, Ger.S.S.	New York	Bremerhaven	39 54 N	69 16 W	do	2p., 17	do	28.50	ENE	WSW, 12	W	WSW, 12	SE-SSW-W.
Executive, Am.S.S.	Lisbon	New York	40 15 N	69 15 W	do	3p., 17	do	28.56	SE	SE, 4	NW	NW, 11	SE-lull-NW.
City of Norfolk, Am.S.S.	Havre	Norfolk	40 21 N	67 17 W	do	6p., 17	Sept. 18	28.77	ESE	S, 10	WNW	WSW, 11	S-WSW.
United States, Dan.S.S.	New York	Christiansand	42 20 N	63 50 W	Sept. 16	2a., 18	do	28.91	ENE	SW, 10	SW	SW, 10	SE-S-SW.
Ile de France, Fr.S.S.	Havre	New York	41 23 N	60 49 W	Sept. 18	7a., 18	do	29.33	SSE	SW, 8	WSW	SW, 8	S-SW-WSW.
Kenbane Head, Br.S.S.	Glasgow	Montreal	50 55 N	58 00 W	do	1a., 19	Sept. 19	28.50	S	SSE, —	NW	S, 9	S-SSE.
Mopan, Br.S.S.	Swansea	Puerto Castilla	17 43 N	81 25 W	Sept. 20	4p., 20	Sept. 21	29.89	E	S, 8	SSW	do	S.
Tivives, Am.S.S.	Cristobal	Habana	19 29 N	85 47 W	Sept. 21	Noon, 21	Sept. 22	29.30	NW	W, 10	SSE	SE, 12	W-SW.
Maine, Dan.S.S.	New Castle	Montreal	58 19 N	32 35 W	Sept. 22	10a, 22	Sept. 23	29.28	WNW	W, 8	SSE	W,10	
Munplace, Am.S.S.	Progreso	New Orleans	21 18 N	89 39 W	do	4p., 22	Sept. 22	29.34	N	NE, 9	SSE	NE, 9	NE-E.
Morazan, Hond.S.S.	Vera Cruz	do	20 35 N	95 00 W	Sept. 24	5a., 24	Sept. 24	29.47	SW	SSW, 10	SSE	SSW, 10	SSW-S.
San Lamberto, Br. S.S.	Tampico	Tuxpam	21 01 N	97 16 W	do	2p., 24	do	[2] 29.19	W	WSW, 10	E	WSW, 10	W-WSW-S.
Adria, Ger.S.S.	In port of Tampico.		22 24 N	97 00 W	do	8p., 24	Sept. 25	28.86	NW	NE, 12		SE, 12	N-NE-SE.
Cavina, Br.S.S.	Avonmouth	Barbados	31 52 N	36 01 W	do	7p., 24	Sept. 24	29.54	ESE	WNW, 8	NW	WNW, 10	ESE-W-NW.
Exiria, Am.S.S.	Faro	New York	36 34 N	38 05 W	Sept. 25	10p., 25	Sept. 26	29.40	SE	NW, 10	WNW	NW, 10	E-N-NW.
Holystone, Br.S.S.	St. Thomas, Virgin Islands.	London	36 52 N	37 10 W	do	11p., 25	do	29.67	N	NW, 11	W	NW, 11	NNW - NW - WNW.
Black Tern, Am.S.S.	New York	Antwerp	48 48 N	29 12 W	Sept. 27	Noon, 27	Sept. 27	29.55	SE	SSE, 9	SW	SSE, 9	SE-SSE-S.
Milwaukee Ger.M.S.	Galway	New York	52 18 N	26 00 W	do	Mdt., 27	Sept. 28	29.46	SSE	S, 10	WNW	S, 10	SE-S-SSW.
Virginia, Am.S.S.	Habana	Cristobal	18 38 N	83 07 W	Sept. 20	8p., 20	Sept. 20	27.40	ENE	Calm	S	NE, 12	NE-SSW.
NORTH PACIFIC OCEAN													
Golden Horn, Am.S.S.	Moji, Japan	Shanghai	31 10 N	123 50 E	Sept. 2	3a., 3	Sept. 3	28.12	NE	Calm	WNW	NE, 12	ENE - Calm - WSW.
Clydefield, Br.S.S.	Woosung	Los Angeles	31 20 N	121 30 E		4a., 3	Sept. 4	29.59		NNW, 8	NW	NNW, 8	
Empress of Russia, Br.S.S.	Vancouver	Yokohama	38 38 N	144 40 E	Sept. 4	10a., 5	Sept. 6	29.25	E	S, 8	WSW	S, 8	None.
President Cleveland, Am.S.S.	Seattle	Japan	51 28 N	163 20 W	Sept. 5	10a., 6	do	29.16	SSE	N, 9	W	N, 9	ESE-N-NW.
Seattle, Am.S.S.	do	Yokohama	45 20 N	159 36 E	Sept. 8	6a., 8	Sept. 8	29.65	WSW	WSW, 8	WNW	W, 9	None.
President Cleveland, Am.S.S.	do	Japan	49 17 N	176 33 E	Sept. 9	Noon, 9	Sept. 12	29.43	S	SW, 5	NNE	W, 8	S-SW-W.
City of Elwood, Am.S.S.	Shanghai	Los Angeles	36 20 N	145 57 E	Sept. 15	10p., 15	Sept. 16	29.94	do	S, 7	SSE	S, 8	None.
Golden Peak, Am.S.S.	Portland, Oreg.	Yokohama	40 24 N	149 05 E	Sept. 16	2a., 17	do	29.67	do	SSE, 3	do	S, 9	SSE-SW-NW.
City of Elwood, Am.S.S.	Shanghai	Los Angeles	[1] 41 35 N	161 25 E	Sept. 18	6a., 19	Sept. 19	28.71	SE	SSE, 10	SSW	SSE, 10	SE-S.
President Jackson, Am.S.S.	Victoria, British Columbia.	Yokohama	52 20 N	147 46 W	Sept. 19	4a., 19	do	29.53	N	NW, 6	NNW	NNW, 8	WNW - NW - NNW.
Fernbrook, Nor.M.S.	Shanghai	Victoria	50 20 N	132 45 W	Sept. 21	3p., 21	Sept. 22	29.21	W	WNW, 8	W	WNW, 8	W-WNW-W.
Juyo Maru, Jap.S.S.	Muroran	Seattle	46 24 N	157 20 E	Sept. 25	4a., 26	Sept. 27	29.63	ENE	NE, 7	E	E, 9	NE-ENE.
Glasgow Maru, Jap.S.S.	Yokohama	Seattle	42 51 N	142 05 W	Sept. 27	10a, 27	Sept. 28	29.56	SW	WSW, —	W	WSW, 10	SW-WSW.
Manini, Am.S.S.	Seattle	Honolulu	47 00 N	128 06 W	do	10p., 27	do	29.36	S	S, 9	WSW	S, 9	S-SW.
Ogura Maru, Jap.M.S.	Yokohama	Los Angeles	38 33 N	155 46 E	Sept. 28	Noon, 29	Sept. 29	29.58	do	SW, 7	NW	W, 8	SSW - SW - WSW.
Texas, Am.S.S.	Port Real, Luzon.	San Francisco.	41 45 N	179 05 W	Sept. 30	8a., 30	Oct. 1	29.49	WSW	W, 7	do	NW, 8	W-NW.

[1] Position approximate. [2] Barometer uncorrected.

NORTH PACIFIC OCEAN, SEPTEMBER 1933

By WILLIS E. HURD

Atmospheric pressure.—The Aleutian LOW was persistent through September 1933, with average center over the Gulf of Alaska (mean pressure at Kodiak, 29.69 inches). Pressure was below normal along the entire American coast from Kodiak eastward and southward, with the point of greatest departure, −0.18 inch, at Juneau. Over most of the remainder of the North Pacific, pressures were somewhat above normal, except in the extreme southwestern part, where Manila was 0.06 inch below.

High pressure during the greater part of the month covered most of the central part of the ocean.

Cyclones and gales.—While depressions were prevalent over northern waters, gales were infrequent and wind forces as a rule did not exceed 8 or 9. The deepest and most active storm center of the month, with pressures below 29 inches, lay off the Canadian and lower Alaskan coasts on the 27th and 28th. Rather widespread gales attended its slow movement eastward. On the 27th, for instance, a whole gale (force 10) from west-southwest was reported in 43°N., 142°W., and on the 28th Tatoosh Island experienced a 62-mile south wind (force 10).

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, September 1933, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Point Barrow	29.93	+0.03	30.46	1	29.60	20
Dutch Harbor	29.78	+.02	30.52	15	29.10	12
St. Paul	29.78	+.07	30.36	15	29.28	12
Kodiak	29.69	−.02	30.18	1	29.16	26
Juneau	29.74	−.18	30.23	5	28.96	28
Tatoosh Island	29.90	−.11	30.30	30	29.42	21
San Francisco	29.90	−.04	30.13	18	29.68	7
Mazatlan	29.76	−.06	29.84	1, 9, 18–20	29.58	16
Honolulu	30.06	+.06	30.15	14	29.94	30
Midway Island	30.10	+.09	30.18	19	29.96	14
Guam	29.83	.00	29.90	18, 27, 29	29.74	8
Manila	29.77	−.06	29.90	20	29.62	16, 17
Naha	29.83	+.07	29.98	10, 30	29.46	1
Chichishima	29.89	+.03	30.06	8	29.66	21
Nemuro			30.38	11	29.58	1

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

In the American tropics the American S.S. *Java Arrow* reported a moderate gale (force 7), with 0.06-inch fall in pressure, while west of Manzanillo, Mexico, on the 13th, and the observer noted that "apparently there was a storm of some intensity to the west of the ship." This

center was not identified, however, in any other observations reaching this office. During the night of the 13th–14th squally weather accompanied by southwest to west winds of force 7–8, but no depression of the barometer, occurred in the neighborhood of 12°–13°N., 96°–97°W.

Typhoons.—On August 29 a typhoon was reported as organizing about midway between the Marianas and the Philippines. On the 31st it lay south of Naha, when one Japanese ship reported a gale of force 9 in the vicinity to the Tokyo Meteorological Office. The typhoon began to recurve from this point and on September 1 lay between Naha and the China coast, whence it pursued a northerly and later a northeasterly course, until it was lost to observation near the coast of Kamchatka on the 7th. It attained full hurricane force on the 2d, if not earlier, when 100 miles or so east of Shanghai. The American S.S. *Golden Horn* (Capt. J. B. Knowles, master; Second Officer E. M. Black, observer), Moji to Shanghai, encountered winds of force 12 from northeast and east-northeast from about 8 p.m. of the 2d until after 1 a.m. of the 3d, and was in the typhoon's vortex from 2 to 3 a.m. of the 3d, lowest barometer 28.12, with a dead calm prevailing at 2:30 a.m. The observer commented upon the tremendous seas experienced prior to entry into the vortex, and upon the abnormal lessening and absence of confusion of the seas within the center. "Birds of many different types", he said, "littered the decks; over 300 were counted on the bridge alone. All were exhausted, even the Arctic tern, which is a very strong bird." The *Golden Horn* was then in about 35 fathoms of water. The west-northwesterly winds which followed the center did not reach their highest force (10) until 7 a.m. On the 5th fresh gales (8) from this storm were reported along both east and west coasts of central Japan, and strong gales (9) on the 7th in the Okhotsk Sea.

On September 9 a depression originated southeast of Yap. It moved along a generally northwest course until the 17th when, east of Taiwan, it turned northward across the Eastern Sea, then suddenly swerved across southern Japan and died out to the eastward on the 20th. This disturbance appears to have been of considerable depth on the 18th and 19th, but the Tokyo reports show no wind forces higher than 9 occurring in the Eastern Sea on those dates.[1]

Other minor disturbances of the Far Eastern tropics were (1) a depression of the 13th-18th which, originating near the western Marianas, moved northward past the Ogasawara Islands and caused gales of force 9 near 40° N., 150° E.; and (2) a disturbance of unknown intensity which gathered east of the Philippines on the 8th and moved northwestward into the northern part of the South China Sea, where, with slow westward progression, it continued during the 10th to 15th.

Fog.—At least 17 days with fog were reported along the California coast between San Diego and Eureka. Between Eureka and Vancouver Island fog occurred on 13 days. Along the northern steamship routes it was observed on 1 to 5 days, the localities of most frequent occurrence lying south and southwest of the Aleutian Islands.

TYPHOONS IN THE FAR EAST, SEPTEMBER 1933

By Rev. C. E. DEPPERMANN, S.J.

[Assistant Director, Philippine Weather Bureau, Manila, P.I.]

(1) *September 10.*—There are indications that this small but interesting typhoon started in mid-China Sea about September 8 and then traveled northeast to the west Balintang Channel, just northwest of northern Luzon. As usual, it was on the intertropical front (hereafter called more briefly the "tropical front") between the southwest monsoon and the trade wind. When definitely located on September 10, it had recurved westward and continued in this direction until it reached the Gulf of Tonking, where it filled up and disappeared. Why? The southwest monsoon stream had divided, the main portion crossing the Philippines to enter the typhoon of September 11; the rest was almost entirely blocked from reaching the typhoon by the mountain ranges of east Indo-China.

(2) *September 11.*—This typhoon started on the eastern branch of the tropical front. On September 9 there were strong suspicions of some depression passing between Guam and Yap, since the barometers of these two stations fell considerably (1.5 to 2 mm is "considerable" for these tropical stations). The southwest monsoon in typhoons still in the growing stage seems to occupy a V-shaped sector pointed northward. A little consideration will show that the center of the disturbance could already have passed the line (NE-SW) joining Guam and Yap and yet give no wind shift to southwest at the more southerly station, Yap. In fact, winds and cloud directions may seem to indicate a disturbance still to the south of Guam. This shift to southerly winds did not come until the 10th, when the front passed through Yap. On the 12th, as the typhoon came nearer to the Philippines, the front from the typhoon to the islands was very neatly given by the wind directions of 2 ships, 1 above and 1 below the front. It may be noted in passing that an almost infallible sign of a typhoon to the east of the islands, even before any fall of the barometer, is the presence of squally winds from the southwest sweeping through the islands on their way to feed the typhoon. On nearing the islands, the typhoon gradually recurved northward without touching them. The situation on September 17 is quite instructive. The typhoon was just below Ishigakajima in the Nansei group. From thence the front extended toward Guam, with trade wind to the east and southwest monsoon to the west. Again, from the typhoon over to mid-Indo-China, there was a sharp front between strong southwest monsoon winds and equally strong northerly winds from the Formosa Channel. Many ship reports from the China Sea enabled us to mark this front with the sharpness almost of a knife. In fact, on this front, close to western Luzon, a "baby" typhoon started, with barometers down to about 746 mm and wind force 10 to 11. Speaking rather timidly from observations only of the present year, this north-pointing V-sector of the southwest monsoon, with trade wind to the east and northerly Asiatic air to the west, seems to be typical of typhoons which curve northward and are soon to enter the eastward-moving circulation. The very moist southwest monsoon also seems to be the "feeder" of the typhoon by reason not of temperature differences but of the vast energy it can release by condensation of its ample supply of water vapor (cf. Refsdal, Der Feuchtlabile Niederschlag, Geofys. Publ., vol. V, no. 12, p. 62, ff. and other Norwegian publications). By the 17th, the typhoon had increased much in intensity, passing over Ishigakajima, which station was temporarily disabled, giving no more weather observations until the 20th. The storm continued northward until about 100 miles east of Shanghai. The *President Cleveland* just about this time (Sept. 19) was close to the center, and reported 726.7 mm, wind force 12, tremendous sea. Two Japanese ships sent out SOS. As far as could be ascertained from newspaper reports, only one of these

[1] For a detailed account of this storm, see the following article on typhoons by the Rev. C. E. Deppermann, S.J.

ships was accounted for some days later. Already on the 18th the cessation of strong winds in the China Sea indicated that the storm had become occluded, with the southwest monsoon forced out, leaving the typhoon to join the east-moving circulation and the front between polar air and the trades. In fact, with decreasing intensity, the typhoon on the 19th while in the Yellow Sea turned quite sharply eastward, cutting across southern Chosen (Korea) and lower Japan, curving to the southeast on the 22d, and passing beyond our maps.

(3) *September 19.*—It is just possible that the "baby" typhoon mentioned in (2) lazily traveled northward until it showed itself more emphatically on the 19th just northwest of northern Luzon, but there are no data to confirm this except rather strong winds in northern Luzon on the evening of the 18th. However, after the southwest monsoon had broken connection with the typhoon up north, the trade wind surged in with a rush on the 19th through the channel between Luzon and Formosa and, meeting the southwest monsoon still in the China Sea, either pushed the "baby" typhoon westward, or else started a new typhoon along the now rebuilt tropical front. This typhoon passed rapidly west-northwestward to just below Hong Kong, and dissipated soon afterwards when it entered the mainland.

(4) *Sept. 26.*—This storm was first discerned as usual between Guam and Yap on the tropical front, along which it traveled in a westnorthwest direction. As the storm progressed, the front did not as usual move quite rapidly through the Philippines northward, but remained near the southernmost end of the Islands, indicating that the typhoon was not fed by a very strong stream. In fact, as the typhoon passed through northern Luzon, the southwest monsoon sector was found to be very narrow and the typhoon very mild, doing practically little damage. In the Islands, the lowest barometer seems to have been only 745 mm. Contrary to what is often asserted in books, this typhoon though so small had no difficulty in surmounting the mountain ranges of Luzon, over a mile high. Why did not this typhoon recurve? For some days previously a large high pressure area had built up over China and Japan, forming a front (the polar front we may call it) between north Asiatic air and the trade wind all the way from east of northern Japan down to Indo-China; but the trade wind divided into two parts near the Nansei (Loochoo) Islands, one stream going northeast, the other roughly southwest. The typhoon was caught in the more southerly stream and hence made its way gradually toward the polar front which it apparently seemed to reach near the Philippines. While in the China Sea indications are that the southwest monsoon was squeezed out entirely, and the typhoon progressed along the polar front in a westerly direction until at the time of writing (Oct. 3), it passed very close to Phulien in Indo-China, having increased slightly in intensity.

In conclusion, it may be added that in following fronts through the Philippines, the writer has been greatly aided by the direction of motion of the lower clouds. Quite early the Manila Observatory recognized the value of such observations as an aid in locating the center of a typhoon (usually on the line perpendicular to the lower cloud direction), and hence this information has been included in the telegrams sent by our weather observers to the Manila central station. The ground winds are much influenced by topography and by the land and sea breeze, but usually the lower clouds are free from these influences and give quite faithfully the direction of the general air stream. This is a marked help when fronts are weak, as often happens in the islands, and their detection through rain areas, temperatures (almost hopeless in the Tropics!) and barometric pressure proves illusive. Since the islands are narrow, it has also been found necessary to draw half-millimeter isobars to bring out many salient facts. The writer is convinced that if all the observatories in the Far East, and for that matter throughout the world, reported lower cloud directions, the tracing of general air streams and consequently of fronts, would be greatly facilitated.

CLIMATOLOGICAL TABLES [1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September 1933

[For description of tables and charts, see REVIEW, January, p. 37]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	79.6	+3.9	Madison	102	17	Prattville	41	22	2.30	−1.05	Primrose Farm	6.23	Newton	0.00
Arizona	77.8	+3.2	Gila Bend	116	[1] 6	Williams	32	25	1.55	+.40	Tonto Ranger Station.	6.13	5 stations	.00
Arkansas	78.6	+4.2	Hope	102	18	Dutton	41	21	5.10	+1.77	Grannis	14.92	Magnolia	.17
California	65.4	−2.1	Brawley	117	6	Tule Lake	19	21	.14	−.33	Crescent City (near)	4.51	96 stations	.00
Colorado	62.5	+4.7	Eads	104	18	2 stations	17	[1] 16	1.87	+.56	Northdale	5.25	Cheyenne Wells	.08
Florida	81.8	+2.3	Vernon	103	15	do	47	22	7.69	+.90	Davenport	19.25	Cottage Hill	.32
Georgia	78.5	+3.0	Millen	103	17	Blairsville	36	21	4.15	+.47	Dover	13.65	Newnan	.61
Idaho	55.5	−1.3	Grand View	100	5	Warren	11	26	.92	−.09	Wallace	4.44	2 stations	.00
Illinois	73.2	+6.1	Greenville	103	10	Mount Carroll	36	29	3.72	+.14	Roberts	9.25	McLeansboro	1.28
Indiana	72.4	+5.2	Edwardsport	105	7	Marengo	37	21	4.94	+1.57	Salamonia	10.47	Princeton	1.72
Iowa	69.4	+5.7	Keokuk No. 2	105	[1] 9	Webster City	29	27	4.16	+.37	Rock Rapids	7.89	Williamsburg	2.13
Kansas	74.3	+4.7	Lincoln	103	10	Burr Oak	34	27	2.25	−.52	Chapman	9.00	2 stations	T
Kentucky	74.3	+3.7	3 stations	98	10	Greensburg	40	21	5.03	+2.10	Salvisa	13.75	Middlesboro	1.73
Louisiana	81.7	+3.7	Monroe	101	19	2 stations	45	[1] 21	1.74	−2.18	New Orleans No. 2	4.28	Logansport	.12
Maryland-Delaware	70.2	+2.4	13 stations	94	[1] 7	do	37	30	3.21	−.02	Keedysville, Md	6.65	Princess Anne, Md	1.15
Michigan	64.2	+4.0	Owosso	103	8	Vanderbilt	25	12	3.56	+.33	Calumet	8.39	Ludington	.95
Minnesota	63.2	+4.1	Maple Plain	100	8	Leech Lake Dam	25	29	3.07	+.16	Pigeon River Bridge	10.51	Campbell	.45
Mississippi	80.6	+4.7	Magnolia	104	19	Duck Hill	44	21	1.90	−1.18	Columbus	4.70	Bay St. Louis	.10
Missouri	74.6	+5.4	2 stations	102	9	Grant City	36	27	4.38	+.32	Dexter	12.02	Bowling Green	.73
Montana	55.3	+.6	5 stations	97	[1] 4	Loweth	7	[1] 15	.85	−.54	Haugan	3.98	Cut Bank	.00
Nebraska	69.1	+5.3	O'Neill	104	5	Harrison	29	26	2.38	+.24	Fremont	7.33	Merriman	.35
Nevada	63.2	+2.4	Logandale	112	6	San Jacinto	14	28	.14	−.28	Arthur	.98	19 stations	.00
New England	61.4	+1.1	North Grosvenor Dale, Conn.	94	27	Falls Village, Conn.	25	13	6.43	+2.76	Provincetown, Mass	15.76	Jackman, Maine	1.28
New Jersey	68.0	+2.1	Indian Mills	93	27	Layton	38	13	6.07	+2.51	Little Falls	10.86	Pemberton	2.70
New Mexico	68.0	+3.5	Carlsbad	101	26	Therma (near)	26	20	1.29	−.32	Carlsbad Cavern	4.88	Ione	.00
New York	62.8	+1.6	Letchworth Park	92	8	Gabriels	25	12	4.02	+.64	Rifton	10.32	Rochester	.71
North Carolina	75.1	+4.1	3 stations	99	[1] 25	Cullowhee	33	22	2.96	−.98	Hatteras	13.63	Durham	.17
North Dakota	60.9	+4.5	2 stations	101	18	Willow City	22	26	.79	−.86	Hillsboro	2.71	2 stations	.20
Ohio	69.1	+3.5	Bowling Green	101	8	3 stations	38	28	4.65	+1.67	New Bremen	9.12	Lock No. 23	1.87
Oklahoma	78.4	+4.2	Alva	105	23	do	44	20	3.48	+.47	Pryor	9.23	Beaver	.01
Oregon	55.9	−1.6	Prairie City	95	3	Seneca	9	30	1.71	+.47	Headworks	14.96	Valley Falls	T
Pennsylvania	66.3	+2.2	Sharon	98	8	Corry	32	12	4.66	+1.20	Mauch Chunk	11.67	Ridgway	2.23
South Carolina	77.8	+3.3	Garnett	100	17	Walhalla	42	[1] 21	4.06	−.04	Charleston	13.04	Winthrop College	.83
South Dakota	66.7	+5.2	Kennebec	109	5	2 stations	23	26	1.21	−.48	Canton	4.36	Oelrichs	T
Tennessee	76.2	+4.8	Halls	99	16	Elkmont	38	21	3.55	+.52	Tiptonville	7.66	Tullahoma	.91
Texas	81.1	+3.7	2 stations	107	[1] 16	Booker	43	19	2.57	−.30	Harlingen	18.25	2 stations	.00
Utah	64.2	+3.7	St. George	104	4	2 stations	19	[1] 16	.55	−.48	Monticello	3.02	Deseret	.00
Virginia	73.0	+4.4	2 stations	98	[1] 25	Emory	37	22	1.81	−1.22	Mount Weather	8.49	Roanoke	.18
Washington	55.3	−2.9	Wahluke	94	4	2 stations	20	[1] 2	3.42	+1.59	Elkpark (near)	15.45	Wahluke	.22
West Virginia	70.3	+3.9	2 stations	98	[1] 8	Bayard	35	30	3.71	+.81	Davis	6.81	Union	.67
Wisconsin	64.4	+4.0	New London	101	8	Long Lake	23	29	3.30	−.33	River Falls	7.75	Kewaunee	.72
Wyoming	57.0	+2.5	Colony	100	4	Dome Lake	10	26	.89	−.27	Pine Bluffs	2.79	2 stations	T
Alaska (August)	52.8	−.9	View Cove	86	24	Allakaket	18	29	3.50	+.01	Cordova	19.58	Barrow	.03
Hawaii	73.6	−1.2	Molokai Ranch	92	23	Kanalohuluhulu	46	1	3.46	−2.28	Papaikou (Mauka)	18.06	10 stations	.00
Puerto Rico	78.4	−.2	San German	97	12	Guineo Reservoir	52	11	9.96	+1.92	Rio Blanco	18.55	Mona Island	1.30

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, September 1933*

[Compiled by Annie E. Small]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							62.8	+2.0										82	5.85	+2.7										6.2		
Eastport	76	67	85	29.82	29.90	-0.13	56.1	+0.3	73	6	62	41	11	50	24	53	52	89	5.04	+2.3	12	6,131	sw.	30	e.	17	7	5	18	7.0	0.0	0.0
Greenville, Maine	1,070	6		28.75	29.90		55.7		78	2	65	33	15	47	31				4.40		13	3,632	se.	20		12	9	8	13		.0	.0
Portland, Maine	103	82	117	29.79	29.91	-.14	61.0	+1.4	82	9	68	41	12	54	27	56	53	80	6.07	+3.0	17	5,400	w.	26	nw.	10	10	10	10	5.4	.0	.0
Concord	289	70	79	29.61	29.92	-.14	60.9	+1.6	88	27	71	33	12	51	33				4.54	+1.1	15		nw.								.0	.0
Burlington	403	11	48	29.47	29.91	-.15	61.0	+.7	81	27	70	38	12	52	28				2.86	-.6	13	5,621	s.	30	se.	20	6	7	17	6.7	.0	.0
Northfield	876	12	60		29.94	-.12	57.4	+1.3	86	27	69	29	12	46	35			86	2.17	-.9	13	4,162	s.	25	sw.	27	3	12	15	7.1	.0	.0
Boston	125	106	165	29.78	29.92	-.15	65.8	+2.6	86	27	74	47	12	58	25	59	56	77	10.94	+7.8	15	5,904	w.	26	n.	17	7	11	12	6.0	.0	.0
Nantucket	12	14	90	29.89	29.90	-.18	66.0	+3.2	78	6	71	52	15	61	16	61	59	86	7.54	+5.1	9	9,439	sw.	54	ne.	17	11	7	12	5.9	.0	.0
Block Island	26	11	46	29.89	29.92	-.16	65.6	+2.2	79	9	70	54	15	61	15	62	60	87	8.54	+5.9	12	10,199	w.	50	n.	17	9	9	12	6.0	.0	.0
Providence	160	215	251	29.75	29.92	-.15	65.0	+1.8	81	6	73	45	12	57	25	60	57	78	6.20	+3.0	13	7,369	nw.	41	nw.	6	10	9	11	5.5	.0	.0
Hartford	159	122			29.94	-.13	65.6	+3.9	84	6	74	44	12	57	29				5.36	+1.9	10	4,757	s.				6	12	12		.0	.0
New Haven	106	74	153	29.82	29.93	-.14	66.6	+3.1	85	9	74	49	13	59	28	61	58	78	5.05	+1.5	10	6,099	s.	28	ne.	17	5	12	13	6.4	.0	.0
Middle Atlantic States							70.7	+3.7										78	3.64	+0.4										5.7		
Albany	97	107	115	29.83	29.93	-.14	64.8	+1.7	83	4	73	41	12	56	29	59	57	80	6.28	+3.2	15	4,356	s.	16	nw.	10	7	12	11	6.0	.0	.0
Binghamton	871	60	68	29.02	29.94	-.13	63.2	+1.9	86	8	73	38	13	54	35				4.73	+1.6	11	3,412	nw.	17	nw.	10	4	5	21	7.7	.0	.0
New York	314	414	454	29.60	29.93	-.15	68.8	+2.0	86	27	76	53	16	62	21	62	58	75	8.17	+4.8	15	9,231	nw.	44	nw.	9	7	10	13	6.2	.0	.0
Bellefonte	1,050	5	42	28.86	29.95		63.2		86	8	73	40	30	53	33	59	57	87	5.49		14		sw.				7	10	13	6.2	.0	.0
Harrisburg	374	94	104	29.55	29.94	-.14	68.6		88	25	76	50	30	61	27	61	58	76	3.59	+.5	10	4,747	w.	22	sw.	20	7	11	12	6.1	.0	.0
Philadelphia	114	123	367	29.83	29.95	-.13	71.2	+3.2	91	25	78	55	16	64	22	64	60	74	4.17	+1.0	11	8,487	w.	29	ne.	16	7	12	11	6.0	.0	.0
Reading	323	283	304	29.60	29.94		68.2	+1.9	89	25	76	51	30	61	23	62	59	76	2.84	-.4	13	6,775	nw.	27	nw.	10	11	8	11	5.4	.0	.0
Scranton	805	72	104	29.09	29.94	-.13	64.6	+1.7	86	8	73	41	13	56	31	58	55	77	5.33	+2.2	10	4,244	sw.	21	nw.	10	7	11	12	6.0	.0	.0
Atlantic City	52	37	172	29.88	29.93	-.14	71.6	+4.8	91	9	78	52	23	65	23	66	64	82	4.71	+2.1	8	11,005	w.	47	n.	16	7	14	9	5.7	.0	.0
Sandy Hook	22	10	57	29.91	29.93		69.4		86	7	75	57	23	64	19	64	61	82	5.17	+1.7	12	9,523	w.	38	ne.	17	8	12	10	5.5	.0	.0
Trenton	190	159	183	29.74	29.93		69.0	+2.1	89	27	77	52	23	61	26	63	60	78	4.86	+1.5	13	6,235	w.	26	sw.	28	5	14	11	5.9	.0	.0
Baltimore	123	100	215	29.82	29.94	-.14	73.0	+4.5	94	9	81	55	23	65	27	65	61	72	3.28	-.1	12	6,844	sw.	43	nw.	9	10	10	10	5.4	.0	.0
Washington	112	62	85	29.83	29.95	-.13	71.8	+3.7	94	9	80	52	23	63	30	65	62	78	2.62	-.6	13	4,031	nw.	21	nw.	21	12	10	8	5.2	.0	.0
Cape Henry	18	8	54	29.92	29.94		76.9	+5.1	93	4	83	61	23	71	22	70	68	78	2.29	-.6	7	8,743	sw.	65	ne.	16	12	11	7	4.7	.0	.0
Lynchburg	686	153	188	29.25	29.98	-.10	75.5	+6.5	98	26	89	46	22	62	40				.35	-3.0	7		nw.				18	9	3		.0	.0
Norfolk	91	170	205	29.86	29.96	-.10	77.2	+5.6	94	25	85	56	22	70	27	69	67	78	2.07	-1.2	6	8,050	s.	56	ne.	16	9	9	12	5.5	.0	.0
Richmond	144	11	52	29.82	29.97	-.10	74.4	+3.9	94	26	84	50	22	65	29	67	64	80	1.05	-2.2	7	5,089	sw.	24	ne.	16	8	14	8	5.1	.0	.0
Wytheville	2,304	49	55	27.66	29.96	-.11	70.4	+6.8	89	12	81	46	23	59	39	62	58	74	.30	-3.0	4	4,317	w.	21	nw.	21	12	14	4	4.3	.0	.0
South Atlantic States							78.8	+5.2										79	6.06	+1.8										4.0		
Asheville	2,253	89	104	27.71	30.00	-.07	71.8	+6.8	89	4	83	42	22	61	41	63	61	80	1.79	-1.2	8	4,448	nw.	21	nw.	20	7	19	4	4.7	.0	.0
Charlotte	779	244	267	29.16	29.98	-.09	76.7	+5.2	93	12	85	61	21	69	25	68	63	71	4.69	+1.7	5	7,429	sw.	32	ne.	13	16	8	6	4.1	.0	.0
Greensboro	886	6	56	29.05	29.99		74.6		95	25	86	44	22	63	39	67	64	83	.69		5	5,048	sw.	22	n.	16	14	10	6	4.6	.0	.0
Hatteras	11	5	50	29.92	29.93	-.13	79.2	+4.7	90	10	84	64	23	74	18	74	73	82	13.63	+9.0	6	9,084	sw.	76	nw.	16	18	7	5	3.4	.0	.0
Raleigh	376	103	110	29.57	29.96	-.11	77.5	+6.4	94	12	87	54	22	68	28	68	65	74	.83	-2.8	6	6,051	sw.	29	n.	16	12	13	5	4.3	.0	.0
Wilmington	72	73	106	29.89	29.96	-.09	78.9	+5.8	93	12	87	60	22	71	23	73	71	84	8.27	+3.8	10	5,998	s.	42	nw.	15	14	12	4	3.9	.0	.0
Charleston	48	11	92	29.91	29.96	-.08	81.2	+4.6	95	20	88	65	22	74	20	76	74	82	13.04	+8.5	7	6,867	s.	51	se.	6	15	12	3	3.8	.0	.0
Columbia, S.C	351	41	57	29.60	29.97	-.08	79.5	+5.0	96	11	89	58	22	70	28	71	68	76	2.19	-1.3	5	4,291	ne.	28	ne.	6	16	11	3	3.2	.0	.0
Augusta	182	62	77	29.76	29.95	-.10	79.8	+4.5	95	18	90	57	22	70	33	71	69	77	3.57	+.2	7	3,492	se.	23	ne.	6	14	13	3	3.8	.0	.0
Savannah	65	73	152	29.90	29.96	-.07	81.6	+5.4	97	17	91	64	22	72	25	74	71	80	8.81	+3.4	8	6,845	s.	47	se.	5	19	8	3	3.5	.0	.0
Jacksonville	43	209	245	29.90	29.95	-.05	82.1	+3.8	95	16	89	70	5	75	20	74	72	78	3.76	-3.6	7	7,985	e.	43	se.	5	12	15	3	4.4	.0	.0
Florida Peninsula							82.6	+1.9										78	6.00	-1.2										4.4		
Key West	22	10	64	29.88	29.90	-.04	82.8	+.6	90	6	88	71	1	78	15	76	74	77	3.10	-3.6	12	7,292	e.	42	e.	1	9	16	5	4.8	.0	.0
Miami	25	124	168	29.92	29.95	-.02	82.3	+2.2	92	15	87	71	27	78	15	76	74	76	5.03	-3.3	14	7,376	e.	42	sw.	4	7	20	3	5.2	.0	.0
Tampa	35	88	197	29.90	29.93	-.04	82.8	+2.9	94	22	90	72	29	75	20	75	73	80	9.86	+3.4	8	7,723	e.	46	n.	4	20	8	2	3.3	.0	.0
Titusville	44	5	25	29.90	29.96		82.4		98	17	91	68	29	73	26				5.62		8		se.								.0	.0
East Gulf States							80.4	+4.7										74	2.23	-2.0										3.6		
Atlanta	1,173	190	198	28.77	29.98	-.07	77.6	+5.2	93	18	87	57	21	68	29	68	64	72	1.25	-1.7	7	5,934	w.	25	e.	5	12	12	6	4.2	.0	.0
Macon	370	76	84	29.57	29.96	-.07	78.4	+3.6	96	17	89	51	22	68	37	70	67	76	2.79	-.4	8	4,202	nw.	28	se.	4	13	13	4	4.0	.0	.0
Thomasville	273	49	103	29.66	29.95	-.06	80.8	+4.0	97	17	91	58	22	70	34	73	71		2.80		6		e.									
Apalachicola	36	11	51	29.90	29.94		81.8		95	16	89	65	22	75	22	75			1.14	-7.0	9		ne.				12	16	2		.0	.0
Pensacola	56	149	185	29.89	29.96	-.03	82.0	+4.0	96	16	88	67	21	76	21	74	72	76	.51	-4.8	3	7,468	se.	30	sw.	8	22	6	2	2.7	.0	.0
Anniston	741	9	57				76.8	+5.5	92	30	88	46	22	65	40				1.62		9		nw.				13	13	4		.0	.0
Birmingham	700	11	48	29.22	29.98	-.05	79.7	+4.9	96	25	91	53	22	68	36	69	66	75	2.74	-.6	8	3,643	se.	25	nw.	17	16	9	5	3.6	.0	.0
Mobile	57	125	161	29.88	29.94	-.06	82.6	+4.5	97	20	91	59	22	74	31	74	71	75	1.40	-3.6	5	5,650	n.	26	ne.	5	16	11	3	3.6	.0	.0
Montgomery	218	92	105	29.73	29.97	-.05	81.2	+4.9	97	19	92	57	22	71	32	71	67	72	5.91	+2.9	11	4,040	n.	25	e.	12	19	7	4	3.7	.0	.0
Meridian	375	87	95	29.57	29.96	-.06	80.4	+5.9	97	15	92	50	22	69	40	71	67	73	2.00	-1.0	5	2,963	se.	22	ne.	5	17	11	2	3.4	.0	.0
Vicksburg	247	65	73	29.70	29.95	-.07	81.1	+4.8	95	18	90	60	21	72	28	72	69	75	1.52	-1.4	6	3,959	se.	29	se.	30	14	11	5	4.0	.0	.0
New Orleans	53	76	84	29.89	29.94	-.04	84.0	+4.8	97	17	91	70	5	77	24	75	72	74	3.08	-2.0	9	4,424	se.	36	n.	5	14	15	1	3.6	.0	.0
West Gulf States							81.5	+4.4										78	4.47	+0.8										4.3		
Shreveport	249	92	227	29.67	29.93	-.07	82.8	+5.9	98	17	92	63	21	73	26	75	73	82	1.07	-1.7	3	5,572	s.	27	se.	25	17	8	5	3.7	.0	.0
Bentonville	1,303	11	44	28.58	29.91	-.11	74.7	+5.8	92	18	85	50	20	65	33				8.62		9	3,630	sw.	20	s.	25	11	8	11		.0	.0
Fort Smith	457	79	94	29.44	29.92	-.09	79.7	+5.7	97	18	90	56	21	70	34	71	68	76	7.16	+4.2	9	4,596	e.	29	s.	24	13	12	5	4.3	.0	.0
Little Rock	357	94	102	29.57	29.94	-.09	79.2	+5.1	95	19	88	59	22	70	28	71	68	79	6.00	+2.8	11	4,672	s.	22	nw.	19	16	7	7	4.1	.0	.0
Austin	605	136	148	29.27	29.90		83.4	+5.1	98	20	93	70	15	74	25	73	69	72	3.08	-.3	5	5,038	se.	21	se.	12	11	13	6	4.9	.0	.0
Brownsville	57	88	96	29.75	29.81		81.8	+1.2	91	3	88	72	4	76	15	76	75	87	13.58	+8.1	13	7,262	e.	75	nw.	5	15	10	5	4.2	.0	.0
Corpus Christi	20	11	78	29.87	29.89	-.06	82.4	+2.7	94	3	88	73	4	77	16	77	76	84	4.71	+.2	17	7,738	se.	49	e.	5	6	18	6	5.6	.0	.0
Dallas	512	220	227	29.36	29.90		82.2		96	19	91	68	11	74	21	72	68	68	1.84	-.9	5	6,994	se.	29	s.	10	15	9	6	3.5	.0	.0
Fort Worth	670	106	114	29.21	29.91	-.08	82.8	+5.9	98	19	92	68	11	74	24				4.94	+2.4	8	6,175	se.	27	se.	27	15	11	4	3.3	.0	.0
Galveston	54	106	114	29.85	29.91	-.07	83.8	+3.7	93	17	88	72	24	80	17	77	74	78	3.65	-1.9	7	7,248	s.	31	se.	30	14	12	4	4.1	.0	.0
Houston	138	292	314	29.78	29.92		82.6	+3.6	95	18	90	72	24	75	20				4.47	+.4	6	7,462	se.	27	se.	24	11	14	5	4.7	.0	.0
Palestine	510	64	72	29.41	29.93	-.06	81.8	+4.8	95	18	91	68	11	73	23	72	70	76	1.59	-1.3	8	4,776	s.	23	se.	12	15	8	7	4.2	.0	.0
Port Arthur	34	58	66	29.88	29.92		83.9		97	17	91	71	23	77	21	76	74	80	2.83	-2.0	10	4,978	s.	29	ne.	4	13	16	1	3.9	.0	.0
San Antonio	693	242	301	29.18	29.88	-.08	82.8	+3.8	97	19	92	72	30	74	23	73	70	74	3.18	+.1	7	7,446	s.	28	s.	12	7	16	7	5.5	.0	.0

TABLE 1.—*Climatological data for Weather Bureau stations, September 1933*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.		In.	In.		Miles								0–10	In.	In.
Ohio Valley and Tennessee							73.8	+5.0										75	3.85	+0.9										4.9		
Chattanooga	762	190	215	29.19	29.99	−0.07	77.0	+4.8	92	13	87	53	22	67	32	68	65	74	1.20	−1.9	6	4,387	sw.	23	se.	14	13	13	4	4.0	0.0	0.0
Knoxville	995	79	97	28.95	29.98	−.08	76.2	+5.6	92	25	87	52	22	65	35	67	64	76	3.50	+.8	6	3,550	ne.	21	nw.	28	16	10	4	3.6	.0	.0
Memphis	399	78	86	29.53	29.95	−.08	79.8	+6.2	92	18	88	60	21	72	22	72	69	76	2.94	+.1	9	4,599	sw.	22	n.	28	14	11	5	4.2	.0	.0
Nashville	546	168	191	29.41	29.99	−.07	77.0	+5.2	93	25	88	53	22	66	35	68	65	74	3.66	+.2	9	4,665	sw.	29	s.	13	11	13	6	4.7	.0	.0
Lexington	989	193	230				72.7	+4.2	91	8	83	47	21	63	28				5.47		10		e.				12	10	8		.0	.0
Louisville	525	188	234	29.40	29.98	−.08	75.6	+5.1	94	10	85	56	22	66	29	66	62	73	4.66	+1.9	10	5,747	s.	35	n.	10	13	6	11	4.9	.0	.0
Evansville	431	76	116	29.49	29.95	−.11	77.3	+6.6	95	10	86	54	21	68	26	68	64	74	2.52	−.8	9	5,196	s.	27	sw.	26	14	5	11	4.4	.0	.0
Indianapolis	822	194	230	29.07	29.94	−.12	73.2	+6.3	95	8	82	50	21	64	27	64	59	70	5.27	+1.9	12	6,591	s.	30	nw.	20	13	4	13	5.2	.0	.0
Terre Haute	575	96	129	29.32	29.93		74.5		96	9	84	52	21	64	28	65	61	71	5.16	+1.5	12	5,621	sw.	25	w.	20	14	5	11	4.8	.0	.0
Cincinnati	627	11	51	29.29	29.96	−.11	73.0	+5.9	96	11	84	50	21	62	31	64	61	76	4.72	+2.1	12	4,281	sw.	23	nw.	19	14	5	12	5.1	.0	.0
Columbus	822	216	230	29.10	29.96	−.11	70.4	+3.9	93	9	79	49	28	61	31	62	59	74	4.45	+1.9	10	6,681	s.	31	w.	20	11	6	13	5.0	.0	.0
Elkins	1,947	59	67	28.00	30.00	−.08	67.0	+4.0	86	25	78	44	30	56	36	61	59	87	5.62	+2.5	14	3,494	w.	21	sw.	20	5	14	11	6.0	.0	.0
Parkersburg	637	77	82	29.35	30.00	−.08	71.8	+4.5	92	9	82	47	22	61	36	64	61	79	2.20	−.6	9	3,698	se.	16	nw.	21	10	7	13	5.4	.0	.0
Pittsburgh	842	353	410	29.07	29.96	−.12	69.0	+2.6	91	8	78	50	30	60	29	62	58	76	4.20	+1.6	13	6,241	sw.	28	sw.	20	6	12	12	6.2	.0	.0
Lower Lake Region							66.0	+3.0										74	2.84	−0.1										6.0		
Buffalo	767	243	280	29.10	29.92	−.14	64.5	+2.1	85	2	71	47	11	58	24	58	55	74	.98	−1.9	10	9,666	sw.	45	sw.	26	6	12	12	6.1	.0	.0
Canton	448	10	61	29.42	29.90		61.2	+1.9	83	2	72	34	12	51	32				2.70	−.6	11	4,703	sw.	25	w.	20	6	13	11	6.0	.0	.0
Ithaca	836	74	100	29.04	29.94		63.2	+1.6	87	8	73	37	12	53	36	58	55	79	2.77	−.3	12	5,612	nw.	24	s.	30	3	9	18	7.3	.0	.0
Oswego	335	71	85	29.55	29.91	−.15	63.2	+2.0	84	8	70	42	12	56	27	58	55	77	1.45	−1.3	9	6,013	s.	21	sw.	20	3	11	16	7.0	.0	.0
Rochester	523	86	102	29.37	29.93	−.13	64.6	+2.2	88	8	73	44	12	56	31	58	54	71	.71	−1.7	8	5,210	w.	25	w.	20	5	10	15	6.6	.0	.0
Syracuse	596	65	79	29.30	29.94	−.13	64.4	+2.8	87	8	73	43	12	56	28				1.70	−1.0	10	4,697	s.	19	nw.	10	2	13	15	7.1	.0	.0
Erie	714	130	166	29.17	29.93	−.13	67.0	+3.4	90	8	75	49	28	59	27	61	57	75	3.82	+.4	11	8,905	s.	31	sw.	26	14	7	9	4.8	.0	.0
Cleveland	762	267	337	29.13	29.94	−.12	68.2	+4.3	90	6	75	51	28	61	24	60	56	68	2.73	−.6	10	9,446	s.	43	w.	20	11	8	11	5.3	.0	.0
Sandusky	629	5	67	29.28	29.95	−.11	69.0	+3.7	98	8	78	47	28	60	33				4.38	+1.4	10	6,151	sw.	23	w.	20	6	15	9	6.0	.0	.0
Toledo	628	79	87	29.27	29.94	−.12	68.6	+4.2	95	8	77	51	22	60	26	61	58	74	3.51	+.7	11	6,438	sw.	25	w.	17	13	9	8	4.7	.0	.0
Fort Wayne	857	69	84	29.02	29.94		69.0	+3.5	95	9	78	48	28	60	27	62	59	77	7.44	+4.4	15	5,962	sw.	25	w.	17	10	9	11	5.5	.0	.0
Detroit	730	218	258	29.16	29.94	−.12	68.5	+5.0	97	8	77	50	12	60	29	60	56	71	1.94	−1.0	13	7,059	sw.	30	sw.	17	10	11	9	5.0	.0	.0
Upper Lake Region							64.2	+4.7										75	3.41	+.01										5.5		
Alpena	609	13	89	29.25	29.91	−.12	61.4	+3.8	86	8	70	39	12	53	32	57	54	82	3.77	+.8	16	7,868	nw.	27	sw.	30	10	12	8	4.7	.0	.0
Escanaba	612	54	60	29.24	29.89	−.12	61.1	+4.0	82	19	70	39	29	52	27	55	51	76	2.74	−.6	8	7,180	s.	35	nw.	6	5	17	8	5.9	.0	.0
Grand Rapids	707	70	244	29.16	29.92	−.13	68.0	+5.3	93	8	78	47	29	59	26	60	55	71	3.59	+.1	13	8,266	sw.	43	sw.	25	12	6	12	5.2	.0	.0
Lansing	878	6	88	28.99	29.92		65.6	+4.2	94	8	76	43	29	55	30	60	57	80	5.37	+2.5	12	6,235	w.	29	w.	17	9	10	11	5.3	.0	.0
Ludington	637	60	66	29.21	29.91		64.2	+4.9	85	7	72	43	27	56	28	58			.95	−2.3	9		sw.				9	10	11		.0	.0
Marquette	734	77	111	29.08	29.87	−.13	61.6	+4.1	86	5	70	41	29	53	32	54	50	71	4.03	+.8	9	7,591	w.	33	sw.	29	5	13	12	6.5	.0	.0
Sault Ste. Marie	614	11	52	29.22	29.91	−.11	59.7	+4.2	86	2	68	38	29	51	32	53	50	78	3.59	−.6	11	5,484	nw.	23	nw.	17	12	8	10	5.3	.0	.0
Chicago	673	7	131	29.20	29.92	−.12	69.8	+4.6	96	8	78	48	29	62	25	62	58	73	3.78	+.6	10	7,244	s.	30	w.	17	14	3	13	5.2	.0	.0
Green Bay	617	109	141	29.23	29.88	−.14	65.8	+5.4	96	8	76	41	27	56	30	58	53	70	2.01	−1.5	10	7,970	s.	35	nw.	20	5	11	14	6.2	.0	.0
Milwaukee	681	97	221	29.18	29.91	−.12	68.5	+6.0	95	8	76	47	27	61	25	60	55	68	2.57	−.7	9	9,662	w.	32	nw.	17	11	7	12	5.0	.0	.0
Duluth	1,133	5	47	28.64	29.84	−.14	60.1	+5.0	80	3	69	37	29	51	41	54	50	78	5.14	+1.8	13	8,937	ne.	37	w.	20	7	13	10	5.8	.0	.0
North Dakota							61.6	+4.4										58	0.75	−0.8										4.3		
Moorhead	940	50	58	28.81	29.81	−.15	63.2	+5.0	87	1	75	32	26	51	39	54	47	63	1.11	−1.1	7	6,775	s.	30	nw.	19	10	13	7	5.0	.0	.0
Bismarck	1,674	8	57	28.05	29.80	−.14	62.9	+4.8	97	18	77	30	26	49	45	51	42	55	.37	−.9	6	6,986	w.	35	nw.	18	16	8	6	4.1	.0	.0
Devils Lake	1,478	11	44	28.25	29.81	−.13	60.6	+4.7	93	18	74	31	28	47	42	49	41	59	.60	−1.0	5	7,634	w.	41	nw.	19	12	9	9	4.8	.0	.0
Grand Forks	833	12	67				61.6		86	1	75	32	26	49	37	52			1.80		9		nw.	40	se.	18	7	12	11		.0	.0
Williston	1,878	41	48	27.84	29.80	−.13	59.8	+3.2	96	4	73	32	26	47	44	49	40	57	.93	−.2	2	7,281	w.	38	nw.	18	17	8	5	3.4	.0	.0
Upper Mississippi Valley							71.2	+5.9										71	3.99	+0.4										4.4		
Minneapolis	918	102	208	28.88	29.85		67.4	+5.8	94	8	77	45	27	58	32	57	50	60	3.44	+.3	7	8,377	se.	35	se.	1	12	9	9	4.7	.0	.0
La Crosse	714	11	48	29.11	29.87	−.14	66.2	+4.0	96	8	77	36	27	55	37	59	55	75	4.63	+.6	14	3,636	s.	15	s.	25	12	8	10	5.1	.0	.0
Madison	974	70	78	28.87	29.89	−.14	67.2	+4.8	92	8	76	43	27	58	26	59	54	71	3.58	−.1	13	6,371	sw.	24	n.	4	10	9	11	5.0	.0	.0
Charles City	1,015	10	51	28.83	29.89	−.11	66.4	+5.3	95	8	78	35	27	55	37	58	54	73	3.92	+.2	11	5,195	se.	21	w.	19	14	9	7	4.1	.0	.0
Davenport	606	118	143	29.25	29.91	−.12	72.1	+6.5	98	9	83	45	27	62	32	62	57	69	3.04	−.5	8	7,043	sw.	35	sw.	25	14	8	8	4.7	.0	.0
Des Moines	861	5	99	28.99	29.88	−.14	70.5	+4.9	98	9	82	39	27	59	37	62	58	71	2.40	−1.3	7	6,807	s.	32	s.	25	13	11	6	4.0	.0	.0
Dubuque	700	81	96	29.16	29.89	−.14	68.4	+4.4	95	8	79	42	27	58	34	60	55	71	3.28	−.7	13	4,776	s.	35	ne.	4	12	8	10	5.0	.0	.0
Keokuk	614	64	78	29.25	29.92	−.11	73.6	+6.1	97	9	85	46	27	62	36	64	59	68	2.25	−1.6	8	5,092	sw.	21	sw.	25	14	8	8	4.1	.0	.0
Cairo	358	87	93	29.56	29.94	−.11	77.1	+5.6	93	9	85	54	21	69	26	70	68	82	7.81	+4.9	10	4,505	s.	31	sw.	27	14	7	9	4.5	.0	.0
Peoria	609	11	45	29.27	29.93	−.11	72.6	+8.3	100	9	85	43	21	60	39	63	59	74	5.92	+1.9	9	4,103	sw.	20	ne.	4	15	10	5	3.8	.0	.0
Springfield, Ill	636	5	191	29.25	29.91	−.14	75.3	+7.7	98	10	86	53	21	64	30	65	60	69	5.05	+1.4	9	7,355	s.	27	nw.	20	16	5	9	4.0	.0	.0
St. Louis	568	265	303	29.32	29.92	−.12	77.4	+7.3	99	10	87	56	27	68	26	67	62	69	2.60	−.9	9	7,567	s.	31	sw.	25	16	5	9	4.1	.0	.0
Missouri Valley							72.2	+5.7										67	3.70	+0.3										3.7		
Columbia, Mo	784	6	84	29.10	29.91	−.12	74.4	+6.2	96	8	86	49	27	63	37				3.92	−.4	10	5,078	sw.	24	sw.	25	15	10	5	3.5	.0	.0
Kansas City	963	10	86	28.89	29.89	−.13	75.7	+6.8	95	11	85	47	27	66	26	66	61	67	2.69	−1.9	6	5,158	s.	24	nw.	19	15	10	5	3.8	.0	.0
St. Joseph	967	11	49	28.87	29.88		73.4		96	11	85	43	27	62	36	64	60	72	3.44	−.4	12	5,399	sw.	23	nw.	19	15	11	4	3.3	.0	.0
Springfield, Mo	1,324	98	104	28.56	29.93	−.10	74.4	+5.5	91	18	83	54	27	66	27	67	65	77	7.02	+3.5	11	5,879	s.	22	w.	28	15	7	8	4.2	.0	.0
Iola	984	11	50	28.87	29.88	−.13	75.4	+5.6	93	17	86	47	27	65	33				4.06	−.9	7		s.				14	8	8		.0	.0
Topeka	987	65	87				74.4	+5.7	97	9	86	44	27	63	33				2.30	−1.5	6	6,303	s.	31	s.	25	17	8	5	3.4	.0	.0
Lincoln	1,189	11	81	28.62	29.86	−.13	71.5	+5.1	98	10	83	37	27	60	34	62	58	70	4.81	+1.8	7	7,387	s.	38	w.	25	16	8	6	3.5	.0	.0
Omaha	1,105	115	122	28.72	29.87	−.13	71.6	+4.8	97	8	82	38	27	61	32	62	57	67	4.72	+1.5	9	5,646	s.	31	n.	1	18	6	6	3.5	.0	.0
Valentine	2,598	47	54	27.20	29.87	−.09	67.2	+4.7	99	5	82	37	30	53	48	55	47	59	.37	−.9	4	6,462	w.	31	sw.	5	16	7	7	3.7	.0	.0
Sioux City	1,135	94	164	28.66	29.84	−.14	69.8	+6.4	96	8	81	41	27	59	36	60	54	64	5.83	+2.8	8	8,378	s.	32	nw.	30	15	7	8	4.4	.0	.0
Huron	1,306	59	74	28.47	29.84	−.12	67.4	+6.1	105	5	80	37	27	55	41	56	49	61	1.56	.0	5	7,091	se.	34	nw.	30	15	9	6	3.9	.0	.0

TABLE 1.—*Climatological data for Weather Bureau Stations, September 1933*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.		In.	In.		Miles								0-10	In.	In.
Northern slope							59.3	+1.9										55	0.96	−0.2										3.6		
Billings	3,140	5					59.4	----	97	4	78	28	26	41	60	----	----		.14	----	2	----	nw.	----	----	----	17	6	7	----	0.0	0.0
Havre	2,505	11	67	27.22	29.82	−.12	57.2	+.8	89	17	70	30	26	44	46	47	38	57	.45	−.8	7	7,408	sw.	40	w.	29	13	14	3	3.6	.0	.0
Helena	4,124	89	113	25.70	29.85	−.12	55.0	−1.6	87	5	67	28	25	43	39	45	37	56	.66	−.6	9	6,119	sw.	30	sw.	23	12	10	8	4.5	T	.0
Kalispell	2,973	48	56	26.84	29.88	−.08	52.2	−1.3	82	4	64	27	26	40	40	45	39	67	1.04	−.2	9	4,701	nw.	25	ne.	5	9	6	15	5.8	T	.0
Miles City	2,371	48	55	27.34	29.85	−.10	63.2	+2.0	95	4	76	34	26	50	42	----	----	48	.90	−.1	3	4,857	s.	36	nw.	18	20	6	4	3.1	.0	.0
Rapid City	3,259	50	58	26.52	29.87	−.09	64.7	+4.3	97	5	78	30	26	51	43	53	43	51	.11	−1.1	4	6,039	w.	35	nw.	22	18	7	5	3.2	.0	.0
Cheyenne	6,088	84	101	24.02	29.86	−.10	60.8	+3.8	89	5	73	37	25	48	40	48	40	54	2.06	+.9	9	7,563	w.	38	w.	15	12	13	5	4.4	.0	.0
Lander	5,372	60	68	24.60	29.85	−.11	59.4	+3.7	90	4	76	27	26	43	48	46	33	45	.15	−.8	4	4,733	sw.	47	sw.	15	21	8	1	2.1	.0	.0
Sheridan	3,790	10	47	26.00	29.86	----	58.4	----	96	4	76	26	26	41	59	47	38	58	.51	−.8	5	3,679	nw.	27	sw.	5	20	7	3	2.8	T	.0
Yellowstone Park	6,241	11	48	23.86	29.88	−.09	51.6	−1.8	80	4	65	26	30	38	41	40	30	50	1.73	+.5	7	6,713	sw.	40	sw.	22	17	8	5	3.4	3.5	.0
North Platte	2,821	11	51	26.98	29.86	−.11	69.2	+7.1	96	6	83	42	30	56	43	58	52	66	2.01	+.7	4	5,268	s.	25	nw.	15	16	9	5	3.3	.0	.0
Middle slope							73.2	+5.1										61	1.80	−0.2										3.1		
Denver	5,292	106	113	24.71	29.84	−0.12	67.7	+4.8	96	5	81	43	26	55	39	52	40	45	1.17	+.2	5	5,589	s.	27	n.	25	19	7	4	3.2	0.0	0.0
Pueblo	4,685	80	86	25.26	29.84	−.12	69.8	+5.2	100	6	86	40	27	54	48	53	43	48	.41	−.3	4	4,821	n.	24	nw.	21	21	6	3	2.6	.0	.0
Concordia	1,392	50	58	28.44	29.88	−.11	73.0	+4.7	97	10	85	42	27	61	35	63	58	68	3.47	+.9	5	6,208	s.	25	sw.	25	22	4	4	2.9	.0	.0
Dodge City	2,509	10	86	27.33	29.87	−.11	74.2	+4.8	97	24	87	48	27	62	38	61	55	60	1.01	−.9	4	9,142	s.	35	s.	24	22	6	2	1.9	.0	.0
Wichita	1,358	85	93	28.47	29.86	−.14	76.0	+5.4	96	23	86	48	27	66	33	66	62	70	1.39	−1.7	6	7,695	s.	32	sw.	25	18	5	7	3.8	.0	.0
Oklahoma City	1,214	10	47	28.63	29.88	−.11	78.6	+5.8	95	17	89	55	27	68	30	69	66	73	3.37	+.3	7	6,956	s.	24	se.	25	14	9	7	4.3	.0	.0
Southern slope							79.4	+5.8										63	1.07	−1.4										3.2		
Abilene	1,738	10	52	28.11	29.86	−.10	83.2	+7.9	98	7	94	68	5	72	28	69	64	62	.40	−2.3	3	6,802	s.	22	s.	26	16	11	3	3.2	.0	.0
Amarillo	3,676	10	49	26.23	29.87	−.09	75.7	+6.4	97	23	88	55	27	64	33	62	56	59	.88	−1.4	2	7,082	s.	21	s.	25	19	9	2	2.8	.0	.0
Big Spring	2,537	5	62	27.32	29.87	----	79.2	----	96	23	90	64	19	68	31	68	64	69	.70	----	4	----	s.	----	----	----	21	6	3	3.2	.0	.0
Del Rio	944	64	71	28.86	29.82	−.12	83.5	+4.3	96	4	92	70	24	75	22	72	67	65	1.35	−1.6	6	7,031	se.	26	se.	24	12	14	4	4.7	.0	.0
Roswell	3,566	75	85	26.32	29.85	−.07	75.0	+4.7	94	28	88	58	29	62	34	63	57	62	1.67	−.4	7	5,109	s.	24	ne.	30	23	5	2	2.0	.0	.0
Southern plateau							75.4	+4.6										51	0.81	0.0										2.2		
El Paso	3,778	152	175	26.12	29.79	−.09	79.8	+5.9	96	3	91	63	9	69	29	63	55	50	.99	−.3	2	5,486	e.	41	s.	9	23	5	2	2.1	.0	.0
Albuquerque	4,972	51	66	25.04	29.79	----	70.8	----	92	3	85	50	26	56	37	57	48	54	1.12	----	8	5,282	se.	27	se.	30	20	8	2	2.5	.0	.0
Santa Fe	7,013	38	53	23.31	29.82	−.11	65.5	+4.6	87	6	78	45	26	53	32	51	41	49	1.24	−.2	5	4,236	se.	18	se.	8	19	5	6	3.0	.0	.0
Flagstaff	6,907	10	59	23.39	29.80	−.09	61.9	+6.4	84	4	77	38	28	47	44	50	----	60	1.12	----	5	5,544	n.	23	sw.	24	10	12	8	----	.0	.0
Phoenix	1,108	10	107	28.61	29.72	−.09	86.8	+4.1	110	5	100	63	27	74	38	67	56	43	1.62	+.9	4	4,135	e.	21	sw.	8	23	3	4	2.4	.0	.0
Yuma	141	9	54	29.56	29.70	−.08	87.5	+3.8	111	5	102	61	25	73	44	70	61	50	.20	−.2	1	3,768	sw.	21	s.	20	27	1	2	1.2	.0	.0
Independence	3,957	5	26	25.88	29.84	−.02	70.7	+2.7	94	1	89	46	19	53	43	49	----	----	.00	−.1	0	----	se.	----	----	----	29	1	0	----	.0	.0
Middle Plateau							65.4	+3.5										35	0.35	−0.3										1.7		
Reno	4,532	74	81	25.40	29.82	−.13	63.6	+3.9	91	1	81	37	21	46	44	46	30	35	.00	−.3	0	5,497	sw.	32	w.	20	28	1	1	.6	.0	.0
Tonopah	6,090	12	20	----	----	----	66.4	----	84	1	78	41	26	55	31	46	27	25	.00	----	0	----	se.	----	----	----	----	----	----	----	----	----
Winnemucca	4,344	18	56	25.55	29.88	−.05	59.4	+.2	92	2	80	31	23	39	54	43	28	37	.34	−.1	2	5,452	sw.	29	sw.	14	27	1	2	1.3	.0	.0
Modena	5,473	10	46	24.57	29.80	−.12	65.2	+5.2	89	5	83	37	19	47	48	48	32	35	.05	−.7	1	8,392	sw.	36	sw.	17	26	3	1	1.5	.0	.0
Salt Lake City	4,360	86	210	25.54	29.82	−.13	67.8	+3.4	94	5	81	44	26	55	39	51	36	35	.34	−.6	1	5,868	nw.	24	se.	9	24	4	2	2.0	.0	.0
Grand Junction	4,602	60	68	25.32	29.84	−.11	71.2	+5.0	95	5	84	49	30	58	38	54	41	42	1.04	+.1	8	4,999	se.	23	se.	21	18	9	3	3.2	.0	.0
Northern Plateau							59.1	−1.3										49	0.70	0.0										4.0		
Baker	3,471	48	53	26.38	29.93	−.06	54.2	−1.8	88	33	69	27	30	39	47	45	35	54	.75	.0	8	4,665	se.	22	sw.	20	11	13	6	4.3	.7	.0
Boise	2,739	79	87	27.08	29.90	−.07	61.2	−.7	91	3	76	33	30	47	40	48	34	40	.12	−.4	2	3,785	nw.	18	nw.	14	20	4	6	3.0	.0	.0
Pocatello	4,477	60	68	25.41	29.86	−.10	61.6	+1.4	89	5	76	32	26	47	42	45	29	35	.16	−.6	3	6,489	se.	31	sw.	21	23	2	5	2.4	.0	.0
Spokane	1,929	101	110	27.85	29.88	−.10	56.8	−2.4	83	3	68	30	25	45	35	48	39	58	1.25	+.4	8	4,891	sw.	26	w.	22	10	9	11	5.4	.0	.0
Walla Walla	991	57	65	28.84	29.90	−.10	62.0	−1.8	88	4	73	39	30	51	33	52	42	53	1.27	+.3	10	4,261	s.	23	w.	22	11	12	7	4.5	.0	.0
Yakima	1,076	58	67	28.75	29.90	----	58.6	−2.5	86	2	70	32	25	47	34	49	40	56	.62	+.1	5	4,190	nw.	26	sw.	22	13	13	4	4.4	.0	.0
North Pacific Coast Region							56.9	−1.6										75	3.60	+1.4										6.6		
North Head	211	11	56	29.72	29.94	−.09	54.6	−1.9	62	4	58	44	23	51	15	53	51	89	6.58	+3.6	21	11,800	s.	68	s.	21	4	4	22	7.9	.0	.0
Seattle	125	90	321	29.78	29.91	−.10	57.6	−.5	80	9	64	39	25	51	30	52	48	75	3.02	+1.2	16	7,363	s.	41	sw.	22	2	13	15	7.0	.0	.0
Tatoosh Island	86	10	54	29.80	29.90	−.11	53.2	+.2	59	18	56	45	21	50	10	52	50	90	7.81	+3.1	21	9,583	s.	62	s.	28	3	3	24	8.4	.0	.0
Medford	1,329	29	58	28.52	29.91	----	60.2	----	90	1	76	35	30	44	48	50	41	58	.31	−.2	5	4,307	nw.	27	w.	17	12	11	7	3.9	.0	.0
Portland, Oreg	153	68	106	29.78	29.94	−.09	59.6	−2.1	82	3	67	40	25	52	28	54	49	72	2.97	+1.0	16	4,777	nw.	23	w.	20	3	11	16	7.0	.0	.0
Roseburg	510	75	99	29.41	29.96	−.06	59.4	−3.5	84	3	71	39	30	48	38	52	46	68	.79	−.5	13	3,616	n.	24	sw.	20	9	10	11	5.7	.0	.0
Middle Pacific Coast Region							64.3	−0.5										66	0.24	−0.4										3.0		
Eureka	62	73	89	29.92	29.99	−.02	55.4	−.5	70	5	61	46	23	50	21	53	52	89	.70	−.3	8	4,813	n.	25	nw.	20	9	6	15	6.0	.0	.0
Red Bluff	330	5	58	29.49	29.84	−.09	72.3	−.8	98	1	87	50	21	58	39	56	42	41	.08	−.7	3	4,631	nw.	25	se.	17	25	3	2	1.7	.0	.0
Sacramento	69	106	117	29.78	29.85	−.04	68.3	−1.0	93	30	82	49	12	54	36	56	47	55	.03	−.4	2	5,554	s.	25	sw.	17	28	1	1	.5	.0	.0
San Francisco	155	208	243	29.73	29.90	−.04	61.2	+.3	82	30	68	50	13	54	28	55	52	79	.14	−.3	2	4,904	sw.	22	w.	23	15	8	7	3.8	.0	.0
South Pacific Coast Region							66.6	−3.2										68	0.00	−0.2										3.4		
Fresno	327	97	105	29.49	29.84	−.03	72.4	−1.0	97	1	88	53	5	57	41	57	46	46	.00	−.2	0	4,579	nw.	18	sw.	17	28	2	0	.5	.0	.0
Los Angeles	338	159	191	29.51	29.87	−.01	64.6	−4.4	81	19	73	51	16	56	24	58	54	77	.00	−.2	0	3,651	sw.	13	sw.	9	11	17	2	3.8	.0	.0
San Diego	87	62	70	29.77	29.86	−.03	62.8	−4.3	70	5	67	53	18	59	15	58	56	81	.02	−.1	1	4,789	nw.	19	nw.	18	7	12	11	6.0	.0	.0
West Indies																																
San Juan, P.R	82	9	54	29.83	29.91	----	80.1	−.4	90	13	85	72	16	75	13	----	----	----	7.28	+1.4	21	7,111	e.	34	ne.	3	1	22	7	6.4	.0	.0
Panama Canal																																
Balboa Heights	118	6	97	----	[1] 29.84	+.02	79.3	−.5	87	4	85	71	20	74	15	----	----	[1] 88	5.18	−2.8	17	4,821	s.	26	s.	28	0	6	24	8.5	.0	.0
Cristobal	36	6	97	----	[1] 29.82	.00	81.5	+1.1	91	12	88	72	4	76	18	75	74	[1] 82	9.11	−3.1	22	4,598	se.	27	se.	4	2	12	16	7.4	.0	.0
Alaska																																
Fairbanks	454	68	87	[2] 29.22	[2] 29.74	----	41.8	----	68	7	51	26	20	32	33	38	31	68	.46	−1.0	8	3,478	n.	27	nw.	7	2	7	21	8.0	1.6	.0
Juneau	80	11	50	[2] 29.65	[2] 29.74	----	49.4	----	64	15	55	37	5	44	25	46	41	76	4.56	----	17	4,451	s.	23	se.	7	3	2	25	8.4	.0	.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 30.02	[2] 30.06	----	76.5	−1.7	83	25	81	69	12	72	12	68	64	67	.44	−.8	11	7,918	e.	24	e.	6	6	18	6	5.1	.0	.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service*

SEPTEMBER 1933

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	29.82	29.87	−0.14	58.1	+1.6	66.5	49.8	79	38	4.98	+1.70	0.0
Halifax, Nova Scotia	88	29.62	29.72	−.32	58.4	+.8	65.0	51.8	80	42	5.59	+1.88	.0
Yarmouth, Nova Scotia	65	29.77	29.84	−.21	57.8	+1.7	64.8	50.9	75	41	4.92	+1.31	.0
Charlottetown, Prince Edward Island	38	29.77	29.81	−.20	58.3	+1.0	64.2	52.4	77	43	3.70	+.30	.0
Chatham, New Brunswick	28	29.72	29.75	−.25	57.1	+1.7	68.0	46.2	84	32	3.37	+.66	.0
Father Point, Quebec	20												
Quebec, Quebec	296	29.57	29.89	−.12	57.0	+1.9	64.1	49.8	78	38	2.25	−1.42	.0
Doucet, Quebec	1,236				51.0		62.9	39.2	82	19	2.94		T
Montreal, Quebec	187												
Ottawa, Ontario	236	29.63	29.89	−.15	62.2	+4.8	72.7	51.6	89	36	1.67	−1.02	.0
Kingston, Ontario	285	29.60	29.91	−.13	63.0	+3.0	70.3	55.8	85	40	3.03	+.23	.0
Toronto, Ontario	379	29.52	29.92	−.14	62.8	+3.8	71.8	53.7	90	39	1.35	−1.90	.0
Cochrane, Ontario	930												
White River, Ontario	1,244	28.55	29.86	−.12	50.7	+.4	63.4	38.1	78	20	3.79	+1.02	.0
London, Ontario	808				63.6		74.9	52.3	96	35	2.48		.0
Southampton, Ontario	656	29.21	29.92	−.13	62.0	+4.5	71.4	52.6	87	36	3.61	+.67	.0
Parry Sound, Ontario	688	29.22	29.90	−.13	60.7	+4.7	69.2	52.2	86	35	3.89	+.22	.0
Port Arthur, Ontario	644	29.14	29.85	−.13	58.3	+6.1	67.2	49.4	84	36	4.27	+.79	.0
Winnipeg, Manitoba	760	28.96	29.78	−.16	56.6	+4.1	66.0	47.1	79	32	2.69	+.66	.0
Minnedosa, Manitoba	1,690	27.99	29.78	−.16	53.0	+2.5	63.6	42.5	77	28	2.18	+.82	.0
Le Pas, Manitoba	860				50.6		59.5	41.7	76	28	1.69		.0
Qu'Appelle, Saskatchewan	2,115	27.52	29.74	−.18	52.3	+1.2	63.6	41.0	83	26	1.73	+.40	.0
Moose Jaw, Saskatchewan	1,759												
Swift Current, Saskatchewan	2,392	27.24	29.73	−.19	54.0	+.9	65.6	42.5	83	29	1.85	+.63	.0
Medicine Hat, Alberta	2,365	27.28	29.74	−.18	55.3	+.3	66.8	43.8	87	29	.65	−.53	.0
Calgary, Alberta	3,540	26.11	29.76	−.16	49.0	−.8	60.8	37.3	74	17	.20	−1.16	T
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.22	29.78	−.12	52.3	+3.9	61.3	43.2	80	27	1.90	+.62	.0
Battleford, Saskatchewan	1,592												
Edmonton, Alberta	2,150												
Kamloops, British Columbia	1,262	28.55	29.82	−.15	56.1	−1.3	65.2	47.1	82	33	.86	+.01	.0
Victoria, British Columbia	230	29.64	29.89	−.12	54.3	−.5	60.2	48.3	68	40	2.86	+.70	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20				52.6		55.8	49.3	60	36	12.45		.0
Prince Rupert, British Columbia	170				50.8		57.2	44.4	66	36	9.31		.0
Hamilton, Bermuda	151	29.91	30.07	.00	79.1	+1.7	84.2	74.1	88	69	4.61	−1.90	.0

LATE REPORTS FOR AUGUST 1933

Stations	Altitude	Station reduced	Sea level reduced	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
Cape Race, Newfoundland	99				55.3		62.6	47.9	75	38	9.11		0.0
Winnipeg, Manitoba	760	29.14	29.95	+0.01	66.7	+3.3	79.2	54.3	93	38	3.63	+0.6	.0
Qu'Appelle, Saskatchewan	2,115	27.71	29.92	−.01	64.2	+2.7	78.4	49.9	96	34	2.96	+1.32	.0
Swift Current, Saskatchewan	2,392	27.42	29.89	−.04	66.2	+2.2	81.1	51.4	97	38	4.63	+2.72	.0
Banff, Alberta	4,521	25.50	30.02	+.11	56.3	.0	71.9	40.7	87	30	2.99	+.46	T
Battleford, Saskatchewan	1,592	28.24	29.95	+.04	65.5	+2.9	81.4	49.5	93	30	1.94	−.42	.0
Kamloops, British Columbia	1,262	28.66	29.92	+.01	70.8	+2.2	85.0	56.7	98	46	.28	−.81	.0
Estevan Point, British Columbia	20				57.7		62.6	52.8	73	48	1.26		.0
Prince Rupert, British Columbia	170				59.4		67.6	51.2	82	45	4.52		.0
Hamilton, Bermuda	151	29.93	30.09	−.01	79.8	+.2	85.2	74.3	88	70	6.64	+.56	.0

SEVERE LOCAL STORMS, SEPTEMBER 1933

[Compiled by Mary O. Souder]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Northwestern Iowa, 4 extreme southeastern counties of South Dakota and 4 extreme southwestern counties of Minnesota.	1				$322,000	Rain	Damage to highways, bridges, and railroads; loss to crops; livestock drowned; traffic demoralized; loss due to the suspension of business.	Official, U.S. Weather Bureau.
Chautauqua County, Kans.	1	3:15 p.m.	50		700	Tornado	Property damaged; path 5 miles long	Do.
Fairmont, Minn., vicinity of.	1	5:30 p.m.				Hail	Loss to corn and garden truck	Do.
Cabot, Ark	1			3		Electrical	3 persons killed and 8 injured during storm	Do.
Key West, Fla	1			3		Wind and tidal wave.	Heavy seas washed over boulevard along south beach undermined the sea wall in several places; concrete drive along the breakwater protecting the submarine base at the navy yard was also undermined; motor boat with 3 Negroes aboard lost; minor damage by wind.	Do.
Forestburg, S.Dak	2	9:30 p.m.				Tornadic winds	Telephone and light poles blown down; haystacks and corn fodder blown away; small buildings in town and on nearby farms wrecked.	Do.
Martin County, Minn	2	P.m.				Thunderstorm and hail.	Considerable damage to growing crops	Do.
Lake Okeechobee-Cedar Keys, Fla.	3-4			2	1,000,000	Tropical disturbance and flood.	Communication lines down; a negro killed when his shack blew down; brakeman lost his life when the engine and 7 cars were derailed; citrus growers suffered large loss; part of Tampa under 9 feet of water; floods general over whole central section of State; breaking of dam of Tampa Electric Co., 3 miles northeast of Tampa, caused considerable property loss; much damage to crops reported.	Do.
Texas, coast region	3-5			24	16,900,000	Hurricane with abnormal tides.	Cameron County suffered most; buildings wrecked; fruit trees and crops devastated; tide havoc over vast area.	Do.
Dubuque, Iowa	4					Wind	Telephone, electric and power lines down; corn flattened and much produce destroyed; buildings damaged.	Do.
Grant County, Wis	4				2,000	do	Electric and telephone poles blown down; barn and farm buildings damaged; trees uprooted.	Do.
Charleston, S.C	6	7:30 a.m.			10,000	Tornado and heavy rain.	Property damaged	Do.
Fifield, Wis., and vicinity	8				3,500	Wind and hail	2 persons injured by hail	Do.
Nantucket, Mass	9	3:10-5 a.m.				Thunderstorm	Barn struck by lightning and destroyed	Do.
Tijeras Canyon Ranger Station, near, N.Mex.	9	4 p.m.	[1] 3		11,000	Rain and hail	Loss to crops and damage to roads; path 6 miles long.	Do.
Chouteau County, Mont	9	7:30-9 p.m.	[1] 5-14		10,000	Wind, rain, and hail	Loss to property; considerable wild game and poultry killed.	Do.
Colorado Springs, Denver, Colo., and vicinity.	9			5	30,000	Excessive rains and flood.	Basements of warehouses, stores and dwellings flooded; hundreds of acres of rich truck lands in the valley washed out or covered with mud; many bridges washed out; $30,000 estimated damage to highway between Colorado Springs and Denver only.	Do.
Fort Thompson, S.Dak	10	3 a.m.		8	25,000	Severe thunderstorm and excessive rain.	Damage mainly to highways and bridges by flood waters in creeks and streams; rainfall heaviest in many years; livestock drowned; crops in lowlands destroyed; houses and tents of Indians residing along creeks washed away by flood waters.	Do.
Forestburg, S.Dak	10	P.m.				Tornado	Some damage reported	Do.
Lascar-Cedarwood, Colo	11	do				Rain and hail	Loss to crops; property damage	Do.
Iredell County, N.C	13			1		Electrical	Wife of farmer killed by lightning in kitchen of her home; same bolt struck barn, killing cow and mule in opposite sides of barn.	Do.
Hidalgo County, N.Mex	14	P.m.		1		Heavy rain	Number of cattle drowned	Do.
Omak, near, Wash	14	do				Hail	Much damage to apple crop	Do.
New Haven, Conn	14-15					Wind	Tail of West Indian hurricane; damage to wires and trees.	Do.
Pipestone, Minn., vicinity of.	15				10,000	do	Property damage and crop loss	Do.
North Carolina, extreme eastern portion.	15-16			21	4,500,000	Hurricane	1,000 persons homeless; telephone and telegraph lines carried away; highways and bridges washed out; scores of houses destroyed; hundreds of livestock drowned; great damage to unharvested crops; more cotton destroyed than by the President's plan of plowing it under.	Do.
Tidewater, Va	15-16				250,000	do	Storm tide flooded business section; rowboats and rafts used for transportation; traffic tied up all day; steamer service to bay discontinued; shipping in Hampton Roads at standstill.	Do.
Provincetown-Nantucket, Mass.	17					Rain and gale	Storm of marked intensity; considerable damage to water front; all shipping tied up.	Do.
Block Island, R.I	17					Wind	2 yachts damaged; another sunk in shallow water; large shed blown down; sea rough.	Do.
Scott City, near, Kans	18	4 p.m.	200		1,000	do	Damage to windows, awnings and trees; storm attained tornadic violence.	Do.
Minnesota, Minn., vicinity of.	18	P.m.			18,000	do	Several barns demolished; trees uprooted; loss to crops.	Do.
Butte, Mont	18			1		Electrical	Man killed, another injured by lightning	Do.
Oconto, Wis	19	3 a.m.			5,000	do	Lightning caused fire which damaged lines of Western Union Telegraph Co. and a North Western Railroad box car.	Do.
Northern Idaho County, Idaho.	21	6:30 p.m.				Hail	No damage reported; path estimated to be several miles wide and about 38 miles long.	Do.
Tipsoe Lake Region, Wash. to Mont.	22					Snow and wind	18 inches of snow in Washington and 40 inches reported at Helena; snowplows used to clear the Naches Highway to Seattle; ripe fruit blown off trees.	Do.

[1] Miles instead of yards.

SEVERE LOCAL STORMS, SEPTEMBER 1933—Continued

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Warrenburg, Mo.	23					Electrical	Several buildings burned	Official, U.S. Weather Bureau.
Chautauqua and Cattaragus Counties, N.Y.	25			1		do	Man killed by lightning	
Cambridge, Wis.	25-26	P.m.			$5,000	Tornado	Telephone and electric wires blown down; tobacco sheds demolished; trees blown down.	Do.
Wisconsin Rapids, near, Wis.	25-26				2,000	Wind	Barn wrecked and farmhouse damaged	Do.
Bentonville, near, and Eureka Springs, near, Ark.	26				6,500	Electrical	Barn, general store, and contents destroyed	Do.
Bloomington, Ill.	26				50,000	do	Lightning struck an elevator causing the damage estimated.	Do.
Indianapolis, Ind.	26					Thunderstorm	Power wires, trees, houses, and barns damaged	Do.
Naples, near, Ill.	30			3		Wind	Boat capsized on the Illinois River drowning 3 persons.	Do.

SEVERE LOCAL STORMS, AUGUST 1933 (SUPPLEMENTARY TABLE)

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Hamilton County, Kans.	11	4:30 p.m.	[1] 2		$1,000	Heavy hail	Occurred short distance southeast of Syracuse; crops pounded into ground.	Official U.S. Weather Bureau.
Marshall County, Kans.	14	4-6 p.m.	[1] 1		800	do	Damage to corn crop; path 15 miles long	Do.
Wabaunsee County, Kans.	16	6:30 p.m.	[1] 1		10,000	do	Crop loss; path 5 miles long	Do.
Stevens County, Kans.	19	5:30 - 5:45 p.m.	[1] 2-12		31,000	Heavy hail and wind.	Crops totally damaged; 50 hogs killed; path 25 miles long.	Do.
Stanton County, Kans.	19	P.m.	440		700	Tornado and hail	No details; path 3 miles long	Do.
Harper and Sumner Counties, Kans.	20	3:30 p.m.	200		5,000	Tornado	Almost complete destruction at 2 farmsteads; path 1 mile long.	Do.
Belle Plaine and vicinity, Kans.	20	5-5:15 p.m.	[1] 4		80,000	Tornadic winds and hail.	Wind approached tornadic violence; path 6 miles long; no other details.	Do.
Norwich, Kans, 6 miles southeast.	26	4:30 p.m.	[1] 1		20,000	Tornado	Damage to farm property; path 9 miles long	Do.

[1] Miles instead of yards.

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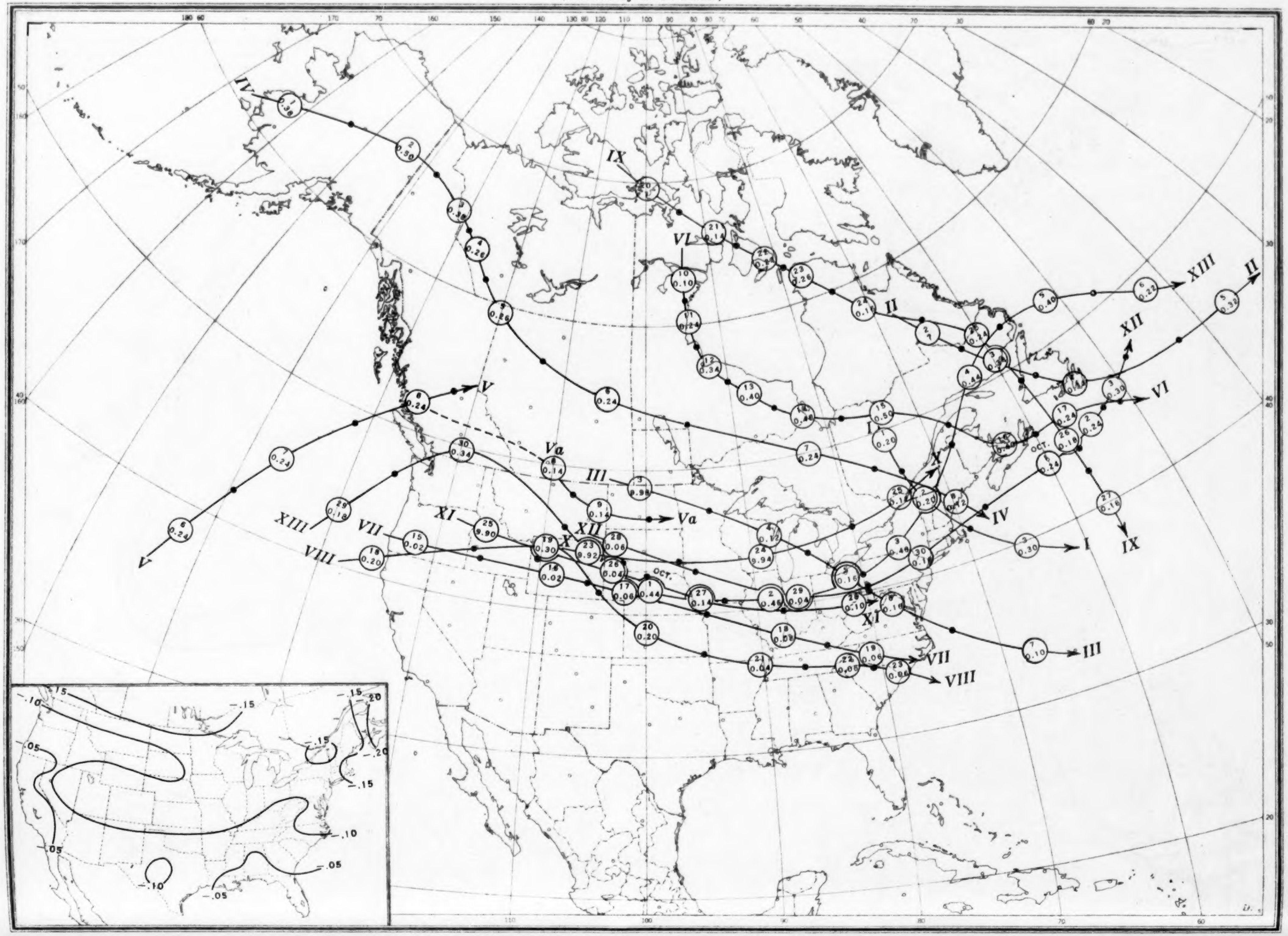
Chart I. Departure (°F.) of the Mean Temperature from the Normal, September 1933

Chart II. Tracks of Centers of Anticyclones, September 1933. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)



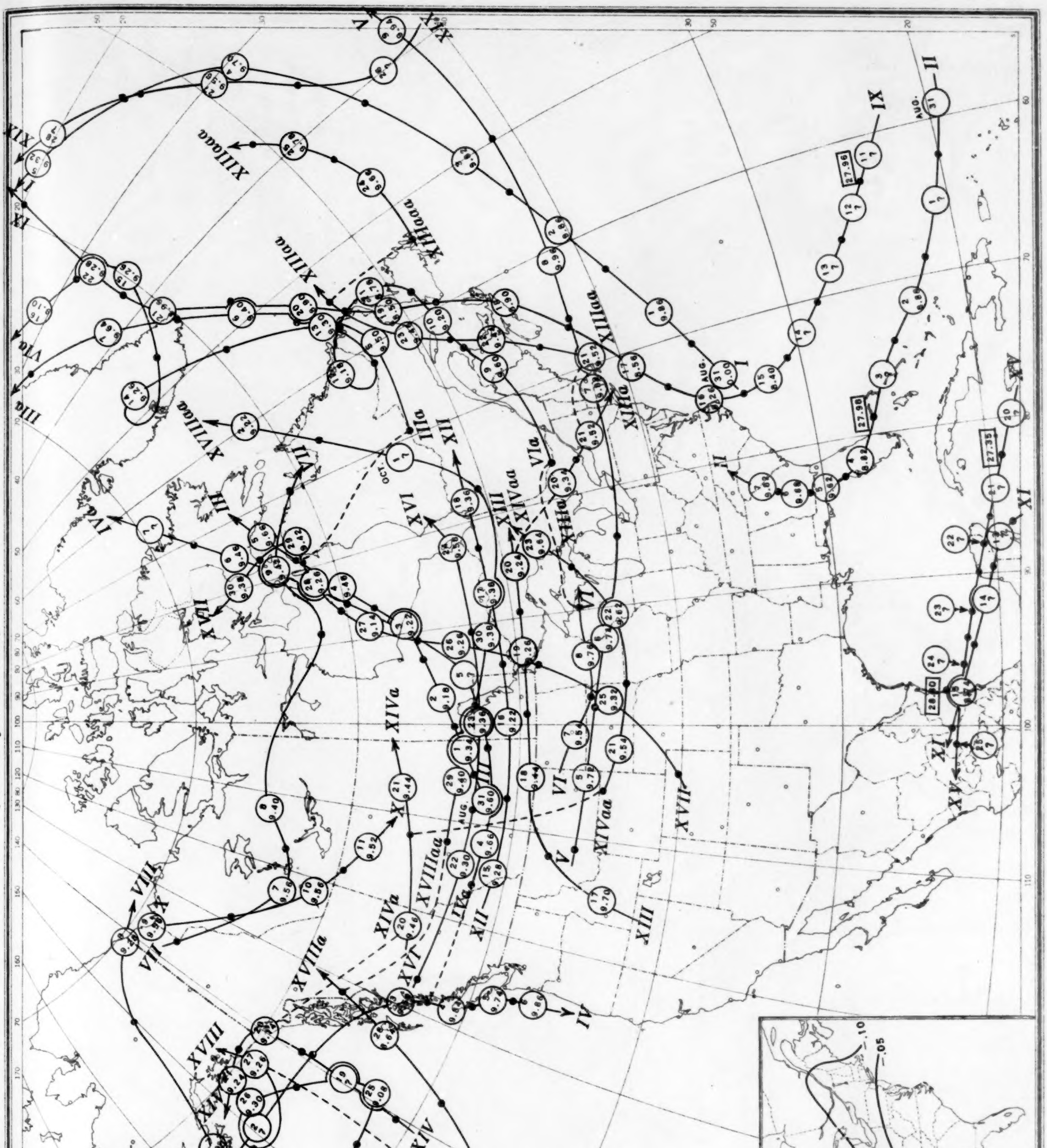
Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, September 1933. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)

Chart III. Tracks of Centers of Cyclones, September 1933. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, September 1933

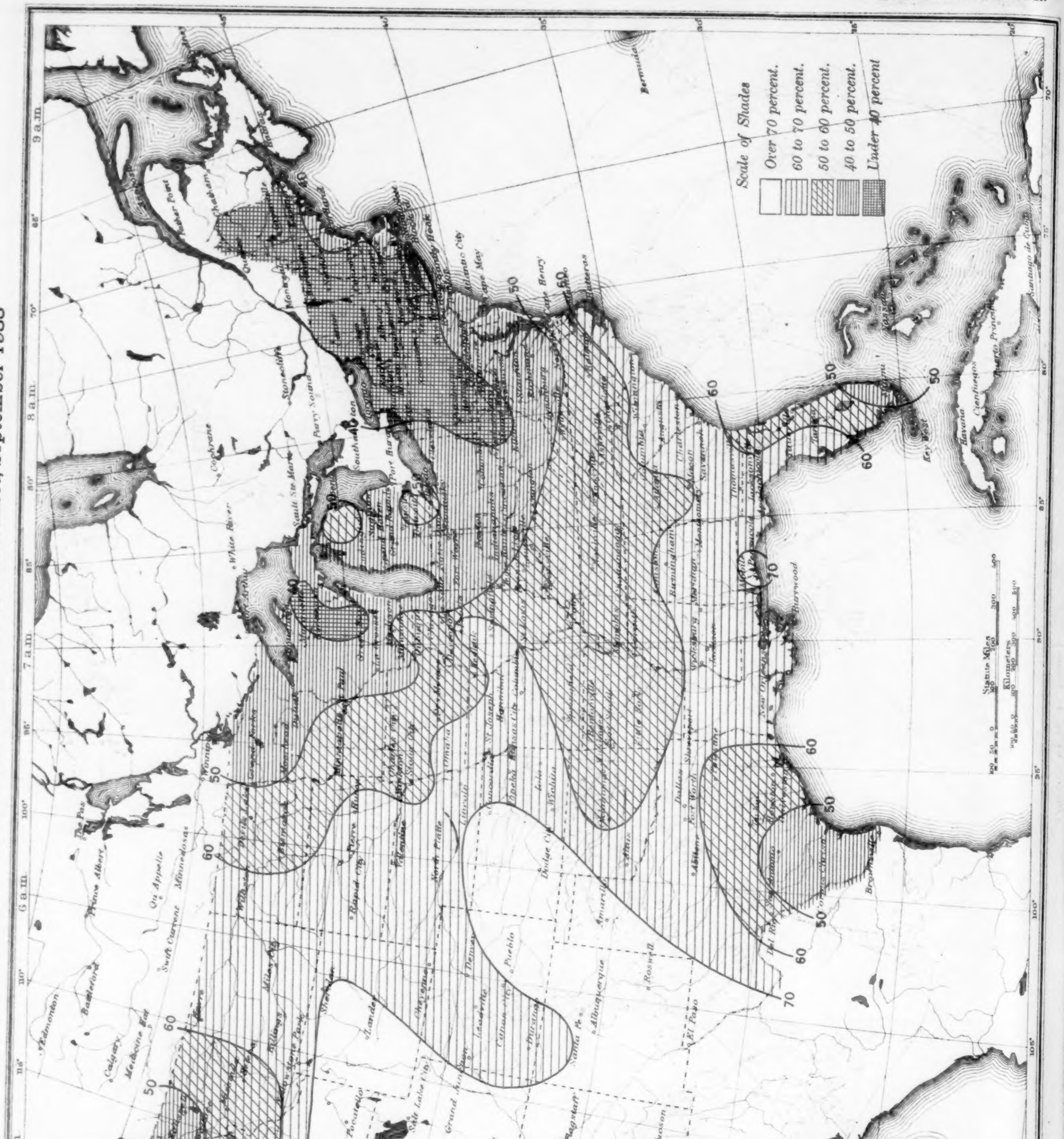


Chart V. Total Precipitation, Inches, September 1933. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, September 1933. (Inset) Departure of Precipitation from Normal

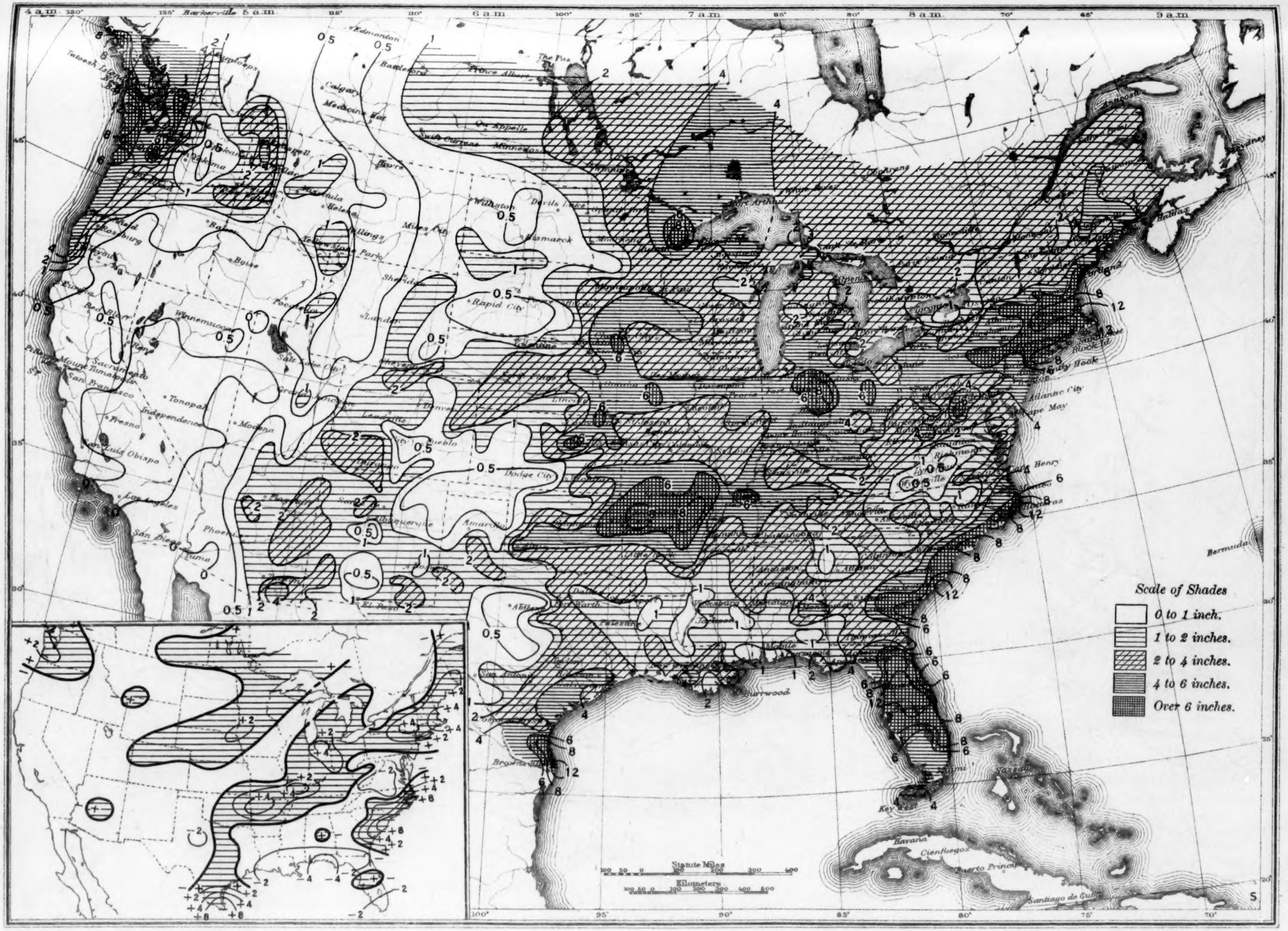
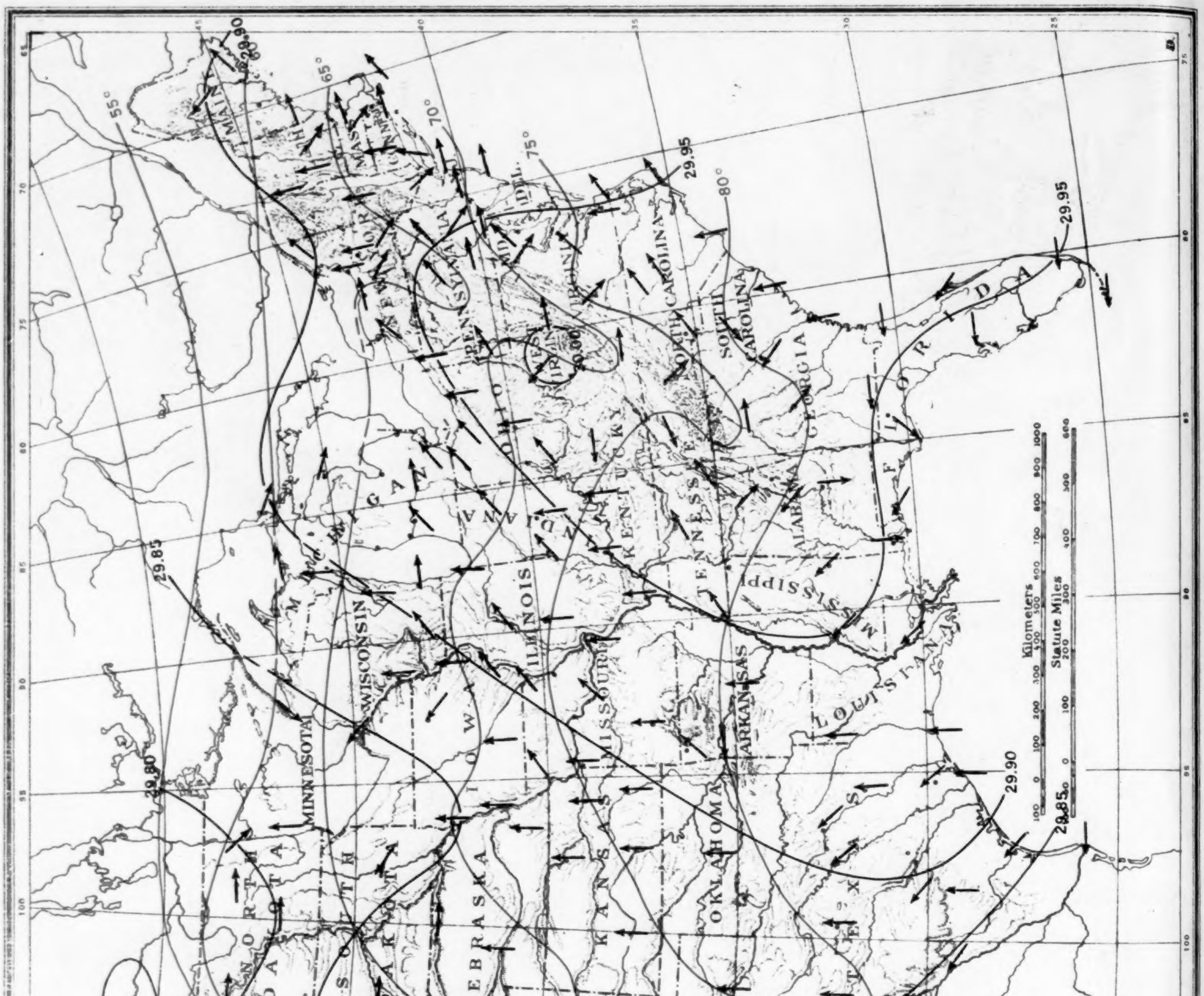


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, September 1933



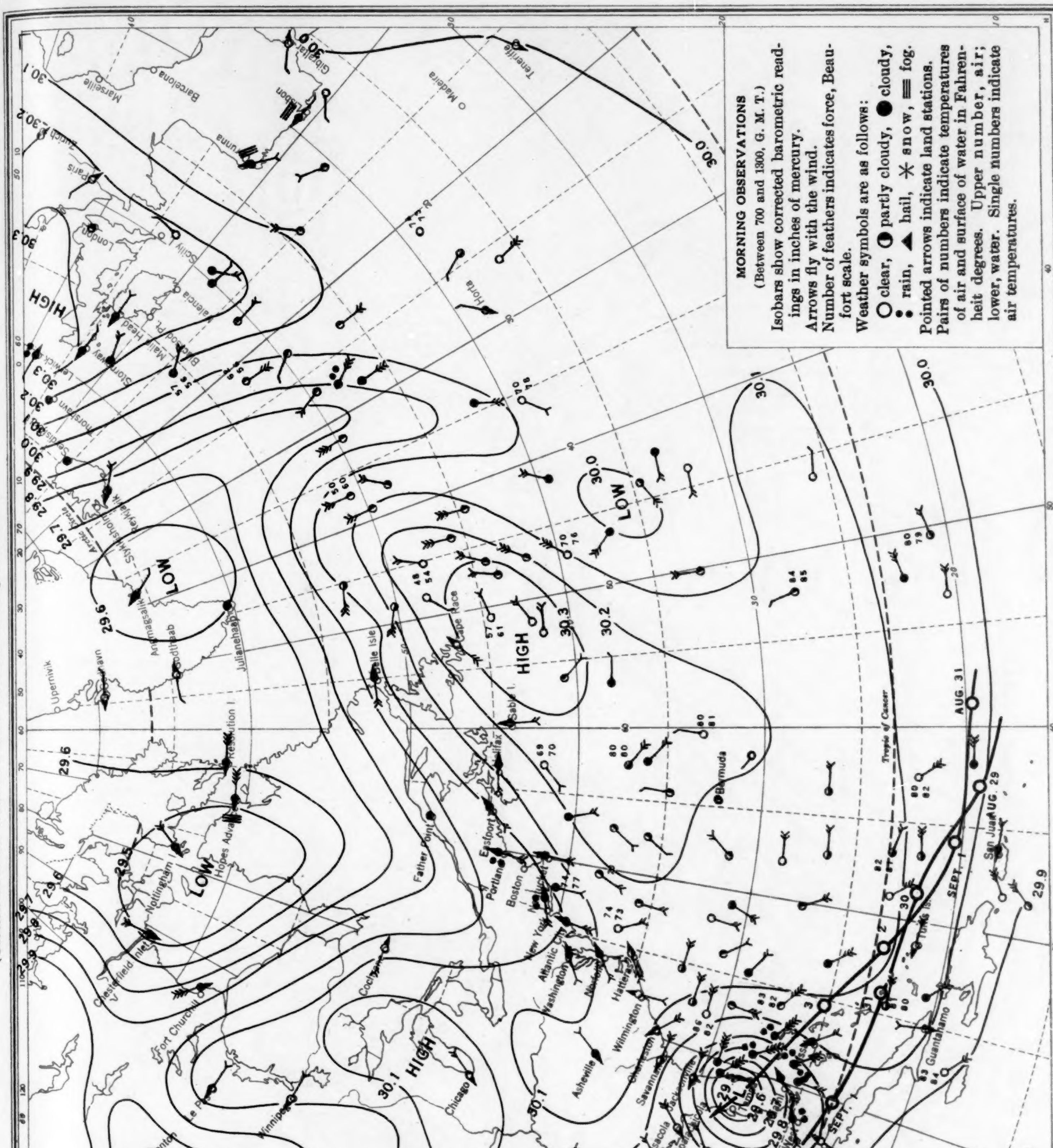


Chart VIII. Weather Map of North Atlantic Ocean, September 4, 1933
(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart IX. Weather Map of North Atlantic Ocean, September 15, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)

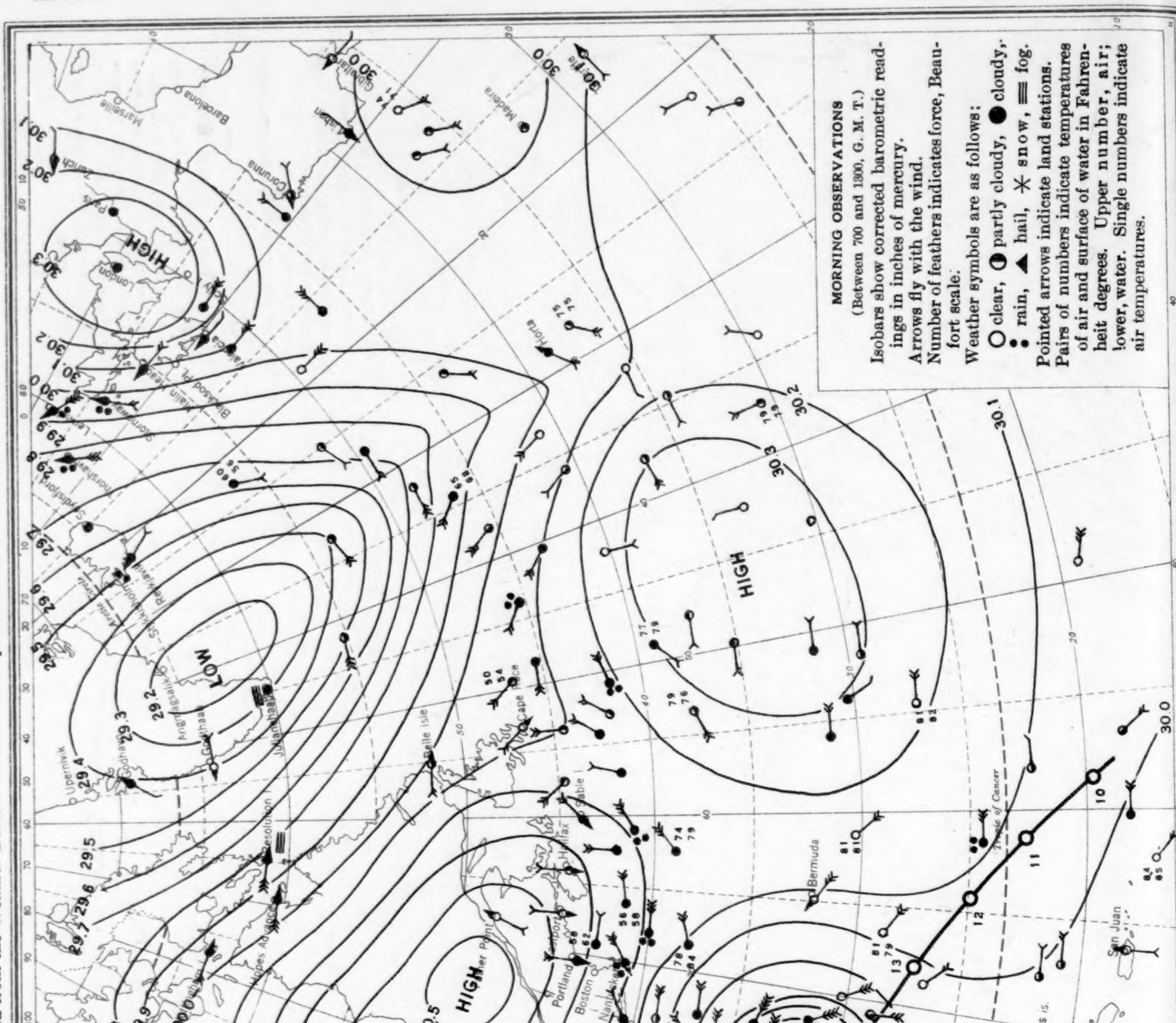


Chart X. Weather Map of North Atlantic Ocean, September 18, 1933
(Plotted from the Weather Bureau Northern Hemisphere Chart)

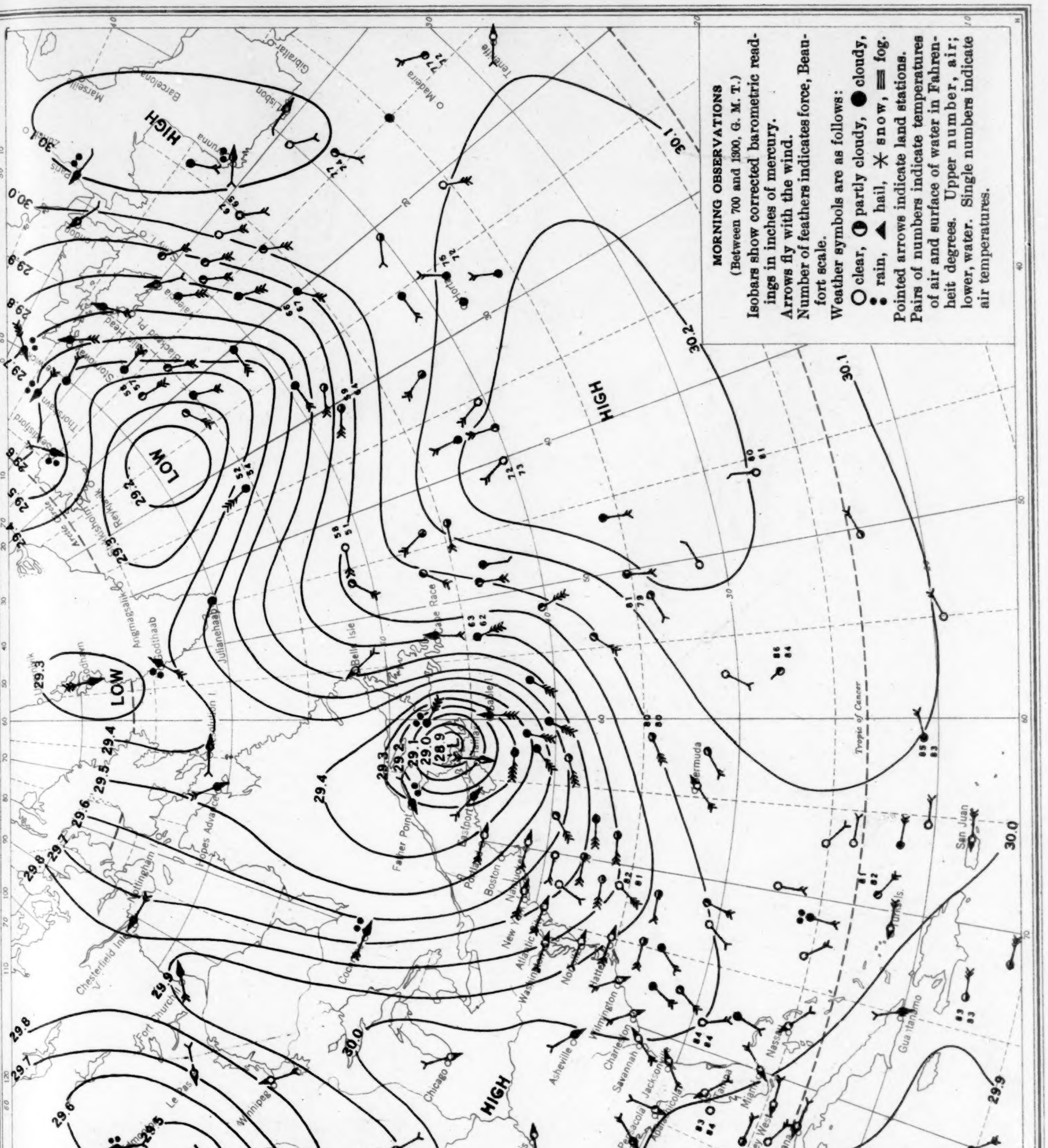


Chart XI. Weather Map of North Atlantic Ocean, September 22, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)